JOURNAL OF THE ROYAL NAVY MEDICAL SERVICE

VOL.
LXXIV
1988

Journal

of the

Royal Naval Medical Service

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Royal Naval Medical Service

VOL.LXXIV
1988

No 1 Spring 1988 Vol 74

JOURNAL of the ROYAL NAVAL MEDICAL SERVICE

 ISSN 0035 9033

Contents

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Contributions should be submitted to the Editor, Journal of the Royal Naval Medical Service, Institute of Naval Medicine, Alverstoke, Hants PO12 2DL, who will arrange for any necessary security clearance. The attention of Medical Branch personnel is drawn to the provisions of QRRN Appendix 35 J.

Manuscripts should be prepared in the Vancouver style. They should be typewritten with double spacing and wide margins and should include: title page, abstract (of not more than 150 words), introduction, method, results, discussion and references, each section commencing on a separate page. A non-eminent length is between 2000 and 3500 words, plus essential tables or illustrations.

Tables and illustrations should be referred to in the text. Tables should be typed in double spacing on separate sheets. Figures should be professionally drawn, making due allowance for the appropriate reduction. Glossy black and white photographs should be submitted whenever possible. Titles and detailed explanations should be given in the legends which should be typed on a separate sheet.

References should be numbered consecutively in the order in which they are first mentioned in the text. At the end of the article the full list of references should give the names and initials of all authors (unless more than six, when only the first three should be given, followed by *et al.*). The authors' names are followed by the title of the article, the title of the journal abbreviated according to the style of *Index Medicus*, year of publication, volume number, and first and last page numbers. Titles of books should be followed by the place of publication, the publishing authority, and the year, e.g.

> Soim NA, Wasserman SI, Austen KF. Cold urticaria: release into the circulation of histamine and neutrophil chemotactic factor of anaphylaxis during cold challenge. *N Engl J Med* 1976; **294**: 687–90.
> Osler AG. *Components, mechanisms, and functions*. Englewood Cliffs: Prentice-Hall, 1976.

1. The Vancouver style. *J roy nav med Serv* 1979; **65**: 179.
2. International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. *Br Med J* 1982; **284**: 1766–70.

NOTICE

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1. RN and RNR medical and dental personnel on the active or retired list, Consultants to the Royal Navy Medical Service, officers and ratings and members of the QARNNS—£6·00 per annum post free (single copies £2·80).
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Editorial

This first issue of 1988 records a change of both Surgeon General and Director Defence Dental Services After three years in post Lieutenant-General Sir Cameron Moffat has retired and the presence of 120 senior Medical Officers from all three Services at his farewell dinner and the sincerity of the tributes underline the success which he achieved in inaugurating a new and contentions organisation His firm courtesy and purposeful approach have encouraged fruitful cooperation between officers with single-Service backgrounds and the result is apparent in the progress made in the period

Surgeon Vice-Admiral Milton Thompson succeeded to the post in January and in addition to his continuing as Medical Director General (Naval) he now takes responsibility for coordinating the activities of three individual Medical Services determining the overall policy and forming the link between the Defence Medical Services and the Central Defence Staff He will be holding the premier post in an organisation consisting of ten thousand uniformed personnel (excluding Reserves) 19 hospitals and a number of Training and Research establishments

In respect of the Dental Branch Surgeon Rear Admiral (D) Coppock has replaced Air Vice Marshal Jones as Director of Defence Dental Services and in addition to his single-Service responsibilities he will coordinate the activities of the three Dental Services The Navy is indisputably well represented at the top for the ensuing few years and the Journal congratulates both officers wishing them well in their challenging and responsible posts

At the time of writing there is a deluge of complaint in Press and Parliament regarding the quality of service provided by the NHS Precipitated by delays in paediatric cardiac surgery the criticisms have gained momentum and they now involve a wide range of services

Although the political opportunists have exploited the situation clouded the issues and hindered balanced judgement there remains considerable concern in well informed circles and Government action is demanded In the long term a change in public philosophy concerning health care may result in a radical reappraisal of funding mechanisms In the short term there will probably be some form of resource injection to contain the situation accompanied by a searching audit of performance at all levels with traditional attitudes and time honoured practices coming under particular scrutiny

The effect on the Armed Services of whatever changes take place remains to be seen as does the outcome of the current proposals to relate the number of training posts in the NHS more closely to the career opportunities It is already possible to identify some changes which if implemented, would strengthen the position of the Royal Naval Medical Service and assist us in the recruitment and retention of medical and nursing staff but undoubtedly there are changes that could work to the detriment of the Service

It has been disappointing to read statements in the Press implying that the Defence Medical Service are not as diligent as they should be in making spare capacity available to the NHS This charge can hardly be levelled at the Naval Hospitals at Haslar and Plymouth where to the benefit of both sides NHS patients are admitted up to the very limit of the available resources and where staff are stretched in the same way as their civilian colleagues

Currently the Royal Navy is becoming increasingly attractive to medical students and doctors as a short or full career opportunity The supply of well-qualified applicants exceeds the requirement for Cadets Direct Entry Offi-

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Surgeon Vice Admiral G. J. Milton-Thompson QHP, FRCP

Surgeon Vice Admiral G J MILTON-THOMPSON QHP FRCP

Surgeon General and Medical Director General (Naval)

Surgeon Vice Admiral Godfrey MILTON THOMPSON was born in 1930 into a family with a naval tradition and was educated at Eastbourne College, Queens College Cambridge and St Thomas's Hospital qualifying in medicine in 1954. On completion of pre-registration hospital appointments he joined the Royal Navy in 1955.

After general duties appointments in the Royal Dockyards in Malta and Chatham and in HMS REGGIO he specialised in medicine in the Royal Naval Hospital Chatham becoming MRCP (London) in 1961. After working in the Hospital for Sick Children Great Ormond Street in 1963 he was appointed Medical Specialist RN Hospital Malta, returning to RN Hospital Plymouth in 1966 where he became consultant physician in 1967. He worked as an honorary research fellow at St Mark's Hospital London for one year in 1970 was elected FRCP in 1974 and appointed Professor of Naval Medicine at RN Hospital Haslar in 1975. He was promoted Surgeon Captain in 1976.

Admiral Milton Thompson attended the 1981 course at the Royal College of Defence Studies before being appointed Deputy Medical Director General (Naval) in the rank of Surgeon Commodore in 1982.

Promoted Surgeon Rear Admiral in May 1984 he was appointed Surgeon Rear Admiral (Operational Medical Services) but in November of that year he succeeded the late Surgeon Vice Admiral Roger Lambert as Medical Director General (Naval). Under the Yellowlees reorganisation of the Defence Medical Services he assumed the additional responsibilities of Deputy Surgeon General (Research and Training) in January 1985. He was promoted Surgeon General in succession to Lieutenant General Sir Cameron Moffat in January 1988 while remaining Medical Director General (Naval).

Admiral Milton Thompson was awarded the Errol Eldridge Prize (1973) and the Gilbert Blane Medal (1976) for his work on the clinical pharmacology of therapeutic agents for peptic ulcer. He has contributed scientific articles to Nature, Gut, Gastroenterology, the Lancet and other learned journals and chapters to Frontiers of Gastrointestinal Research and Goethe's Textbook of Maritime Medicine. He is a member of the Medical Research Society and the British Society of Gastroenterology and is a Fellow of the Royal Society of Medicine and of the Medical Society of London. He was appointed an Honorary Physician to Her Majesty The Queen in 1982 and a Commander (Brother) of the Order of St John in 1986. He is married and lives in Cornwall and is a member of the Naval and Military Club. He collects English paintings of the Norwich School and is interested in fly fishing and other rural pursuits.

Surgeon Rear Admiral (D) D A C Coppock QHDS MSc BDS

Surgeon Rear Admiral (D) D A COPPOCK QHDS MSc BDS

Tri-Service Director Defence Dental Services

Surgeon Rear Admiral David COPPOCK qualified as a BDS at Guy's Hospital in 1954

He joined the Navy in 1955 on a Short Career Commission transferring to the permanent list in 1957 He spent his first two years at sea on the fixed wing carrier HMS EAGLE seeing active service in the Suez Campaign of 1956 From 1959 until 1962 he was appointed to HMS TAMAR, Hong Kong where he held clinics in the Murray Barracks and later Victoria Barracks providing dental care to firstly the Northumberland Fusiliers and later the Warwickshire Regiment

In 1963 he returned to sea serving on HMS HERMES prior to a further foreign tour in Gibraltar looking after the Worcestershire Regiment and the Royal Ulster Rifles

Promoted Surgeon Commander (D) in 1967 he held a series of shore appointments in the UK at HMS DRYAD HMS DAEDALUS HMS COLLINGWOOD and the Naval Dental Clinic in London He was later appointed as Officer in-Charge of the Royal Naval Dental Training School In 1972 an exchange appointment with the USN at the National Naval Medical School BETHESDA Washington D C lead to an MSc Degree in Oral Biology

In 1987 he was promoted Surgeon Captain (D) and held appointments as Director of Dental Training and Research Deputy Director of Naval Dental Services and Command Dental Surgeon to CINCNAVHOME

He was appointed Director of Naval Dental Services in July 1985 in the rank of Commodore On the first of January 1988 he was promoted Surgeon Rear Admiral (D) and became the second Tri Service Director Defence Dental Services

He was married in 1957 to Marie who sadly died in 1985 leaving two daughters One is a General Practitioner and the other a Dental Surgeon (ex RADC)

Among his pastimes Admiral COPPOCK lists flyfishing tennis and golf He is also a keen attender at the theatre

continued from page

cers and Full Career Transfers enabling a high degree of selectivity to be employed To an extent it reflects disillusionment with the NHS but that is by no means the whole story Most candidates and certainly those that are accepted express very positive attitudes to the Royal Naval Medical Service and its role in peace and war In particular there is great enthusiasm for service with the Royal Marines

Rating recruitment is good in some areas less so in others MA recruiting is definitely improving and the MA(Q) ("Female MA) scheme has got off to a good start with recruiting offices over-subscribed at an early stage The importance of getting the correct male/female ratio has been carefully addressed in Headquarters. Recruitment at rating level of qualified technicians and nurses is a great deal more difficult and competing as we are with the NHS and the Private Sector the impact of market forces relating to pay and status looms large and it may loom larger as the NHS is resuscitated

If there is one area in which the Royal Naval Medical Service has automatic credibility in the eyes of the public and the profession it is in the field of Undersea Medicine A great deal of research is pursued in this field and the number of papers presented for publication to this and other Journals is high For that reason and because the Submarine Service constitutes such a vital part of our responsibilities to the Fleet it is planned to devote the next issue to papers relevant to Submarine Medicine and Flag Officer Submarines has kindly consented to write a Foreword

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Editorial Comment

Immediately prior to publication of this issue the Editorial Secretary (Mrs J Southwell) sustained serious injuries in a motorcycle accident We wish her a speedy recovery Some inconvenience to authors and correspondents is inevitable during her absence but it will be kept to a minimum

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Chernobyl: The lessons learnt

R J Carmichael

INTRODUCTION

At 1 23 am local time on Saturday 26 April 1986 the world s worst civil nuclear accident occurred Unit 4 of Chernobyl Nuclear Power Station located some 80 km (50 miles) north of Kiev in the Ukraine exploded (*Fig 1*) One worker was killed instantaneously by the explosion another died within a few hours from extensive burns and the effects of radiation and 29 others died over the next four weeks from the effects of radiation combined in most cases with burns Possibly some thousands of additional cancers will occur as a result over the next 50 years throughout Europe These additional cancers will be caused by the increased radiation dose to the large numbers of people principally living in Europe including European Russia arising from the release of radioactive fission products This cloud initially was windborne towards Scandinavia but subsequent wind changes spread it across central Europe and eventually to much of the Northern Hemisphere The increased radiation doses arise from external doses from ground deposition adding to natural background together with internal doses from inhalation of suspended or resuspended particles and of particular importance in the months and years after the accident from the intake of contaminated food stuffs There are numerous lessons to be learnt from this accident

Surgeon Captain Carmichael is the Head of the Defence Radiological Protection Service at the Institute of Naval Medicine

THE CHERNOBYL REACTOR

Unit 4 as the other three reactors at Chernobyl and the proposed fifth as yet unbuilt reactor was a RBMK design producing 3 700 MW of thermal power and delivering 1 000 MW of electrical power The design dating from the 1950 s uses mildly enriched (2%) uranium fuel moderated by 2 000 tonne of graphite Heat is removed from the reactor by light water that is allowed to boil within the core thus giving a degree of superheat to the steam that is used to power the turbo generators This design would not be acceptable in any Western country principally because

a. This design of reactor has a positive void coefficient. This means that if the water in any of the over 1 000 zirconium alloy pressure tubes forms a steam bubble as it passes through the reactor core, local reactivity increases the nuclear fission chain reaction increases and the power rises causing more boiling and more voids Thus the reactor has the potential for a run away nuclear chain reaction and requires a complex rapidly responding control system to cope with this positive feedback The effect is particularly marked below 20% full power and for this reason operation below this level was prohibited The Russian reactor designers had made the mistake of assuming that the operators would not be forced into these unstable conditions by demands from Moscow

b The control and safety rods are combined and can only be driven into the core mechanically at a relatively slow speed (0 4 m s $^{-1}$)

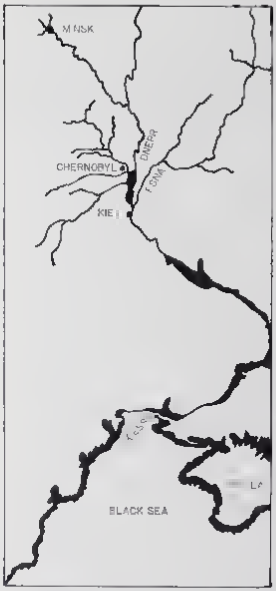

Fig. 1 Map showing location of Chernobyl

The operators can also withdraw more than the specified maximum number of rods

c The emergency cooling and the reactor protection systems can be shut off by the operators

d The protection against pressure tube failure is very limited and inadequate venting of any steam will allow for reaction with hot graphite moderator

Since the Chernobyl accident the Russian RBMK reactors (some 13 were operative in 1986 but up to 25 are built or are being built) have been modified by fitting more numerous and more rapidly acting safety rods and greater fuel enrichment which increases the inherent stability of the reactor as well as a considerable tightening up on adherence to procedures

ACCIDENT SEQUENCE

The sequence that ended with the explosion started some 12 hours earlier when prior to shut down for annual maintenance after a year of high availability and output the station began a trial that had been requested by Moscow and had been attempted twice before The aim was to determine if sufficient power could be generated by the inertia of the turbo generators to power the Emergency Core Cooling System (ECCS) pumps for approximately 40 seconds after the reactor steam supply had been shut off For the trial the load of the ECCS pumps was simulated by the main circulating and feed pumps and the ECCS system itself was isolated The test went wrong right from the beginning when the operators allowed power to fall to below 30 Mw(t) caused by an error in operation of the control system From about 11 pm on Friday 25 April some 2 hours before the explosion the operators struggled to carry out the required test and to control the reactor at powers in the range of 1% to 7% of maximum At these power levels the reactor was at its most unstable and among other things the operators found they had to withdraw all but 6 of the 211 control rods despite the safe minimum being 30 and rules strictly forbidding even Mr Gorbachev himself" from withdrawing more rods than would leave 15 in core and requiring a manual scram if this situation occurred When the trial itself was finally initiated by tripping steam supplies to the turbo generator an irreversible sequence of reactivity additions started caused initially by the thermal effects of main coolant pump run down Although the increasing power transient was detected by the operators, their attempt to stop it by manual scram could not succeed because of the time needed to insert the large number of control rods previously withdrawn Although the exact sequence of affairs will never be known two explosions took place probably caused by the interaction of water with molten fuel and the interaction of hot hydrogen and carbon monoxide mixing with air and exploding as the containment of the reactor vault failed The explosion was about equivalent to

0 5 tons of TNT and lifted the 1 000-ton lid off the reactor Fuel (about 3% of the total inventory) graphite and zirconium were ejected from the reactor causing local fires The access of air to the remaining graphite started a major core fire that lasted for several days Considerable heroism was shown particularly on the part of the firemen and also by the helicopter pilots who deposited some 5 000 tons of sand boron lead etc on top of the reactor Unfortunately although the fire in the core was extinguished this blanket of material allowed the core to heat up again releasing further fuel fission products into the atmosphere, particularly some 10 days after the explosion

It is estimated that the total release of radioactivity to the environment was some 2 000 PBq (54×10⁶ Curies) some 2% of this being Caesium 137 and perhaps 15% to 20% radioiodines mainly Iodine-131

CONSEQUENCES OF CHERNOBYL ACCIDENT

The principal consequences of this accident outside its immediate vicinity resulted from the release to the atmosphere of the radioactive fission products from the uranium fuel These fission products contain a wide range of different isotopes with varying half lives and differing degrees and types of hazard Defence Radiological Protection Service analyses of various samples from BAOR Cyprus and the United Kingdom identified about 20 different isotopes but of these Iodine Caesium and Ruthenium were the most significant

The hazards from any release of mixed fission products to the atmosphere are

a. Direct external irradiation by various mechanisms
b Inhalation
c Contamination of water milk and food stuffs

The direct irradiation hazards including immersion in the cloud were probably not major factors even in the Chernobyl area Sheltering is the most appropriate countermeasure in this case ie going inside buildings shutting doors windows and ventilation Ground deposition was certainly the major factor in the decision to evacuate 135 000 persons from an area 30 kms around the plant In the case of the firemen particular fission products in solution or suspension in the water used for the firefighting which soaked their clothing caused some 20 cases of serious beta burns of the skin as well as contributing to the total body gamma dose of these patients

Beyond the 30 km evacuation zone deposition particularly on the ground but also on the roofs of houses, etc gave rise to an additional dose on top of the natural background doses received by everyone

Inhalation of suspended or resuspended fission products from the cloud will have been important in the vicinity of the evacuated area (30 kms radius) but was unlikely to have been a major problem elsewhere in Europe or the Northern Hemisphere but it did add something to the extra dose total One isotope of particular concern was Iodine 131 and the administration of stable iodine in various forms was much used as a countermeasure to block the uptake of the I 131 into the thyroid gland Contamination of and concentration in foodstuffs is one of the major longer-term problems This is emphasised by the lamb bans still applicable in areas of North West Britain where rainfall during the fission product cloud passage resulted in higher local deposition levels than in the drier areas Caesium is the radioactive isotope of principal concern Caesium-134 with a half life of 2 years is rather less of a problem than Caesium 137 with a 30 year half-life Caesium tends to get into the roots of grasses and other vegetation from the soil and from there to the leaves cropped by sheep in particular but also by cattle Once in the animal concentration is more in the muscles although all parts of the body can be affected

The setting of safe levels of contamination requires a knowledge of the annual consumption of the particular meat and the setting of an annual limit of intake In the case of lamb a limit of 1 000 Bq per kilogram is being used Consumption estimates vary between an average of 7 kg per annum in adults with up to 30 kg in critical groups down to an average of 1 kg per annum for 1-year old children with up to 3 kg in critical groups The annual limit of intake for Caesium 137 for classified radiation workers is 4×10^6 Bq and for Caesium-134 3×10^6 Bq[1] thus a general public consumption upper limit of 3×10^4 Bq of a mixture of Caesiums 134 and -137 appears to be reasonable with average figures less than a quarter of this maximum This assumes that all lamb consumed is at the limit of contamination a very pessimistic assumption

The result of these additional radiation doses to a very large population is fraught with controversy Both the total population dose and

Fig. 2 Map of Europe

the number of extra cancers caused by that dose have considerable uncertainties to them. Just two points can be made however with reasonable certainty. First the additional cancers over the next 50 years due entirely to Chernobyl will not be distinguishable above the natural cancer incidence except perhaps in the 135 000 evacuees even there it is likely to be an increase of no more than perhaps 0.3%. This group will be studied carefully and the Russians have asked for external help in carrying out this study. The second is that the extra cancers caused are likely to be more than hundreds and unlikely to be in the tens of thousands thus some thousands seems a reasonable estimate. For the UK alone the NRPB's estimate is that there may be about 40 extra non thyroid malignancies and perhaps 100 thyroid malignancies unlikely to be fatal.

The acute fatalities from the accident number 31 in all and *Table 1* summarises these. All of these were either workers at the complex or firemen and no members of the general public received immediately life threatening doses. The assessment of doses was made difficult by the inability of the film badges used to measure higher doses indeed some were reported to have been melted during the heroic fire fighting.

Doses were assessed by peripheral blood lymphocyte counts and the lymphocyte chromosomal dicentric aberration test together

Table 1 Summary of fatalities

Dose range	*Numbers*	*Deaths*	*Comments*
Unknown	2	2	1 killed by the explosion 1 died in a few hours of burns and/or the effect of radiation on the CNS
6 to 16 Gy (600 to 1600 cGy) (Russian 4th degree)	22	21	Majority with thermal and/or beta burns
4 to 8 Gy (400 to 800 cGy) (Russian 3rd degree)	23	7	All who died had severe beta burns
2 to 4 Gy (200 to 400 cGy) (Russian 2nd degree)	53	1	
Less than 2 Gy (Russian 1st degree)	105	0	
TOTALS	205	31	

with clinical assessment based on the Russian categorisation of radiation injury. Besides the skin beta burns suffered by many of the firemen, oro pharyngeal effects were noted in many cases almost certainly due to local beta irradiation. Very thick adherent mucus required manual removal, mucolytics and antiseptics including acyclovir. Extensive antibiotic therapy (primarily amino-glycosides and semi synthetic penicillins), intravenous fluid replacement, blood (irradiated to 1 500 cGy to prevent Graft versus Host disease problems), gamma globulin and Amphotericin B (anti fungal agent) were used in treatment.[2] The most effected patients were treated in Moscow with standard reverse barrier nursing including ultra violet air sterilisation. The lessons to be learnt from treating these cases will be examined later in the paper.

THE ACTIVITIES OF THE DEFENCE RADIOLOGICAL PROTECTION SERVICE IN THE CHERNOBYL ACCIDENT

When the news first broke of the Chernobyl accident with reports of contamination being detected in Scandinavia the Institute of Naval Medicine was being inspected by the Surgeon Rear Admiral (Operational Medical Services). On the morning of Tuesday 28 April an evolution was requested that it eventually transpired had originated with a member of INM's staff rather than with SRA(OMS) to carry out an atmospheric air sample. This proved negative as the cloud did not reach the UK until the 1 May.

Subsequent actions included responding to numerous telephone enquiries and the measurement of various types of contamination in the UK, BAOR and Cyprus as well as in ships and aircraft and also analysing samples from other sources.

Telephone queries included the problem of milk from Denmark used by BAOR and the use of swimming pools, sand pits, schools, air conditioning equipment and the advisability of continuing exercises in BAOR. Much of the confusion in BAOR was caused because whereas the Federal Government was giving sensible advice some local Government "green" politicians were making political capital out of scaremongering.

In the UK queries included the need for potassium iodate for personnel (both military and members of the General Public) visiting Scandinavia and Eastern Europe and the need to monitor personnel returning from Eastern Europe. A number of personnel were monitored in the DRPS whole body monitor but only one civilian who had been in Finland at the time of the release reaching there had detectable Caesium 137 in his body. He had been referred via

the British Embassy and his local General Practitioner The whole body monitor detected an increase in background due to the presence of Iodine 131 and significant contamination with six different isotopes was found in its air filter Overall a policy of providing sensible advice to members of the General Public unable to contact NRPB whose switchboard became jammed was adopted One environmental health officer wanted help in persuading a man not to decontaminate himself his family house car and garden with bleach Advice was given to the Defence Medical Services Directorate to answer a question from DHSS on the nursing of contaminated patients

The most major problem found was the contamination of filters in air treatment units particularly in Germany and Cyprus although significant contamination with a mixture of isotopes was found on some filters in the UK A system of work procedure was developed for changing these filters Ship surveys also only showed filter contamination in a few cases One that had returned from the Baltic had 12 detectable radioisotopes on its filter A number of aircraft were monitored but only minimal traces of contamination were found Other samples analysed included local grass samples and milk various food samples from Germany Cyprus Gibraltar (Polish beef and chicken imports) and from Southern Hampshire

A number of local Press briefings were given with mixed results Some resulted in sensible objective reports that helped allay local fears but in one case a reporter who asked about possible extra cancer cases and was told possibly hundreds probably a few thousands but not likely to exceed 10 000 reported ' could cause at least 10 000 cancer deaths in the next 50 years (*Portsmouth Evening News* 2 May 1986) One reporter was whole body monitored with no Chernobyl activity detected

The Nuclear Naval Bases also played active roles in this accident

THE LESSONS LEARNT FROM CHERNOBYL

CLEARLY the importance of the prevention of accidents in nuclear power plants is the prime lesson to be learnt from Chernobyl The extent of the consequences in other countries had not been previously fully realised The need for early notification and good meteorological forecasting not just at low altitudes, is also apparent The need for adequate public information and reassurance to counteract the worst of the scaremongering was clear To provide such information massive resources are needed for monitoring and laboratory analyses. These are already available but need mobilising and coordinating Contamination limits for a wide range of foodstuffs need to be set at sensible but not unreasonably restrictive levels Considerable international collaboration is taking place to action these requirements WHO OECD EEC FAO IAEA IARC UNSCEAR etc all are working on these subjects

The philosophies of sheltering and evacuation need to be put across clearly to the General Public despite the risk of media misrepresentation Early or self evacuation while sheltering is being recommended is the worst option particularly while the cloud is passing but is not likely to be prevented otherwise This accident emphasised the value of sheltering which is likely to be given a higher priority in the future

The medical lessons learnt include

a That beta burns from radioactively contaminated water soaking through clothing need to be watched for and avoided Early monitoring and decontamination reduces this hazard

b That burns exacerbated fluid and electrolyte problems from whole body irradiation which were solved by parenteral fluids electrolytes and nutrients

c Anaemia is associated with burns and is a major problem in burnt and irradiated casualties

d Antifungal and antiviral (especially for herpes) agents are required in addition to broad spectrum antibiotics

e. Fresh rather than stored platelet transfusions are essential In all blood transfusions the lymphocytes must be inactivated This is best done with a 20 Gy (2 000 cGy) radiation dose to the blood

f There is a very narrow window in which bone marrow transplants are likely to be of value Dr Gale of the USA who went to Russia to help with the bone marrow transplants puts this at 8 to 12 Gy (800 to 1 200 cGy) but the Russians consider 10 to 12 Gy more realistic.

g A major radiation-induced oropharyngeal syndrome with erosion of mucous membrane surfaces with very thick mucoid discharges due to a combination of external and local beta irradiation was a major problem

h Comprehensive supportive therapy can

result in survival of patients with doses in excess of 8 Gy (800 cGy)

i Biological dosimetry is possible even for relatively large numbers of casualties, particularly when physical dosemeters are not worn

j Additional information to come to a better informed view of the lethal dose of radiation to 50% of fit uninjured young adults has not been precise enough However an LD_{50} somewhat in excess of 4 Gy (400 cGy) appears certain for burnt and irradiated casualties

k The procedures for the distribution and administration of stable iodine to the general public particularly children, needs to be studied This is being undertaken by the World Health Organisation

ACKNOWLEDGEMENTS

I am grateful for the massive amount of work put in by all the staff of the Defence Radiological Protection Service during a long period following the accident I am also indebted to the staff of the Institute of Naval Medicine for the provision of support services during this period

The following have also provided useful comments on the paper Captain D A McVean BA RN (Chairman Naval Nuclear Technical Safety Panel) Surgeon Captain J R Harrison MSc MB BS MFOM MRCS LRCP RN and Professor R J Berry MD FRCP FRCR FACR MCPS

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A Review of the History of Portsmouth's Armament Depots

C E Pugh

INTRODUCTION

Portsmouth's Royal Armament depot facilities are generally a little known part of MOD(N)'s empire. They occupy a large area of land to Gosport and have an extensive waterfront on the west side of the harbour. Originally an area known as Priddy's Hard was used but this is now being closed and all ordnance transferred to Frater, Bedenham and Elson. These three areas are co-located and situated some two and a half miles from Priddy's Hard. One further depot, Dean Hill, located between Romsey and Salisbury, completes Portsmouth's present-day armament depots.

As a trainee in Occupational Medicine one of my jobs was to help provide an Occupational Health Service for the armament depots. During this appointment I became interested in their history; hopefully others will find it of some interest if only to help them sleep at night!!

I will begin with a general discussion on how the nation's armament depots evolved before turning my attention solely to the Portsmouth area.

ORIGINS OF THE NATION'S NAVAL ARMAMENT SUPPLY DEPOTS

In the early Middle Ages there was no standing army or navy. Wars were waged by armed bands raised by the great nobles and the arms they used were either personal property or, to some extent, provided by the nobles themselves. The King armed his personal retainers in the same way as other nobles and in due course his stock of arms came to be kept in the Tower of London, then the main stronghold of the King. By 1299 this stock of arms was placed under the care of the Keeper of the King's Wardrobe, the personal clothing of the King being known as the Little Wardrobe and the stock of arms as the Great Wardrobe.

With the advent of cannon this Office acquired greater significance: the casting of guns and making of powder being new and difficult arts. In 1414 one Nicholas Merbury was appointed to be 'Master of our Works, Engines, Cannon and other kinds of Ordnance for War' with John Lonth as Clerk. From then onwards a regular succession of Masters and Clerks at the Tower can be traced. Stocks of weapons were also held in other castles in the Kingdom. The latter were under the control of the Governors of those strongholds who appointed their own masters of ordinance and staff. These included master bowyers, master fletchers, master smiths and other mechanics.

In 1546 Henry VIII constituted the Navy Board by Letters Patent and a 'Surveyor of Ships and Master of Ordnance' was appointed for the Navy. This Official did not however take over the custody of stocks or the supply of cannon and ammunition for the Navy. This remained the function of the Master of Ordnance at the Tower and the duties of the Surveyor of Ships seem so far as Ordnance was concerned, to have been limited to such matters as deciding allowances and possibly the training of Naval gunners.

It is well known that corruption was rife at this time with many complaints made about the

Surgeon Lieutenant Commander Pugh is now serving at RNAS Culdrose.

quality of ordnance This led to the appoint ment of a Commission of Investigation and in the Year 1598 the Office of Ordinance was reconstituted by Queen Elizabeth I on lines that were little changed until the Crimean War At the head was the Great Master who supervised the whole by land and sea As assistants he had a Lieutenant who acted as Treasurer being allowed to keep 6d in every sovereign disbursed to cover expenses and salaries a Surveyor who was responsible for the quality and quantity of what was bought a Storekeeper who had custody of the stock a Clerk of the Deliveries who made issues, and a Clerk of the Ordnance responsible for finance

The authority of the Great Master of Ord nance now extended to Woolwich and also to Rochester but elsewhere munitions still re mained in charge of the Governors of fortresses with their subordinate Masters or in the care of Lord Lieutenants of counties Between 1600 and 1660 a standing commission was set up under the Great Master composed of experi enced mechanics to ensure that all arms and armour were put into a fit state

In 1660 after the restoration of the Monar chy work throughout the kingdom was consoli dated under a Master General and attempts made to eradicate longstanding abuses An Order in Council of 1667 committed the care of all forts to the Office of Ordnance and em powered it to call Governors Commissaries and others to account for their acts

Outstations were under the charge of Store keepers who were not allowed to take in or issue anything without an order from the Board and their accounts were submitted to the Tower for examination Moreover the Storekeepers were personally accountable for any deficiency and like the Storekeeper General at the Tower had to provide bonded securities

PORTSMOUTH

It may safely be assumed that in an important fortified port such as Portsmouth there must have existed a Master of Ordnance from very early days He would however have been appointed by and have been responsible to the Governor of the port and not subject to direct control from the Master of Ordnance at the Tower

After 1667 when the Order in Council was made committing the care of all forts to the Master General of Ordnance the Master of the Ordnance at Portsmouth became an appointee of the Board of Ordnance with the title of Storekeeper We may therefore regard the exis tence of an Ordnance Depot in Portsmouth as dating from 1667 or very shortly afterwards

A warrant of 1683 permanently established a Department of Ordnance and listed the follow ing Depots in addition to the Tower the rates shown against each Depot being the yearly salaries of the Storekeepers

	£		£
Chatham	120	Woolwich	40
Portsmouth	120	Plymouth	40
Tilbury	100	Hull	40
Sheerness	80	Berwick	30
Upnor Castle	80	St James Park	20
Windsor	50		

From this it is clear that Portsmouth was from the first a major depot and one of the two most important outside the Tower

From early days the Port Magazine had been situated in the Square Tower at the end of the High Street This Tower continued in use as the Magazine of the Ordnance Depot In 1764 its suitability was criticised on grounds of what we would now call safety distances and in 1779 the explosives were transferred to Priddy s Hard The Old Magazine was then handed over to the Victualling Department

PRIDDY S HARD

Before 1750 Priddy s Hard was an area of partly arable and partly heath land In 1750 by Act of George II and Parliament three parcels of this land totalling some 40 acres, were purchased by the Board of Ordnance from the Vicar of Fareham Thomas Missing and from Jane Priddy A boatyard and wharf were in cluded in the sale The land was required for fortification to extend the Gosport Defence Lines and by 1757–58 these fortifications were completed and became known as Priddy s Hard Fort. Later the derelict boatyard was chosen as the site for a new Naval magazine and in 1768 Royal assent was given to start construction (*Fig 1*)

1770–1845

In this period gunpowder was the only explo sive in service and paper or flannel was used to make the cartridges Solid shot fired from truck carriage-mounted smooth bore cannon were the norm although the French adopted shell and shell-firing guns in 1837 closely followed by the

Fig. 1 The original Magazine at Priddy's Hard Today it forms part of the Royal Navy Ordnance Museum which although not well advertised is an interesting place to visit

British Towards the end of the period case shot and shrapnel were introduced.

Carronades supplemented cannon from 1778 onwards Gun flintlocks began to supersede the slow match/powder horn/vent priming method of firing Cast iron smooth bore guns started to oust brass ordnance from about 1811 Small arms were mostly smooth bore muskets and pistols—there were no machine guns!

Ships were all sailing ships and the period was the heyday of the Navy's fighting sail

The War of American Independence was fought from 1775 to 1781 and England was at war with France from 1793 to 1815

It is against this background that the buildings at Priddy's Hard existing at the time should be viewed Because ordnance and other hardware were stored and maintained at the old Gunwharf in Portsmouth the main requirement for Priddy's Hard was as a magazine for gunpowder storage plus a few ancillary buildings containing support services—nothing else Laboratory requirements at the time were met by the Royal Powder Works at Little Horsey Island

1846–1913

This was a tremendously innovative period for Naval armament There was the evolution from solid round shot to elongated exploding high explosive shell Rifling of guns and small arms became standard practice and new larger calibre guns both muzzle loading and breech loading, were introduced This began in 1861 with Britain's first iron built warship HMS *Warrior* Armour plating was developed and had a significant influence on gun calibre and types of shell

Steam power was harnessed to the screw propeller and so sail gave way to steam Towards the end of the 19th Century mines and torpedoes appeared in service in ever increasing numbers as did machine guns

Explosives other than gunpowder were discovered and some began to be used in service Guncotton was discovered in 1846 and introduced for military purposes in England in 1865 In 1847 nitro-glycerine was discovered in 1867 Nobel produced dynamite later followed by blasting gelatine and in 1888 Nobel also produced ballistite About 1890 Sir Frederick Abel and Sir James Dewar first introduced cordite and from 1895 to 1900 picric acid, lyddite lead azide and CE (composition exploding) all appeared. Although TNT was discovered in 1863 it was not developed as a high explosive in this country until the 1914–18 Great War period. The Crimean War took place in 1854–55 and the Boer War was fought in 1899–1902 So to what extent did these inventions and events affect Priddy's Hard?

All ordnance small arms machine-guns and allied hardware continued to be stored and maintained at the Gunwharf no new buildings at Priddy's Hard were therefore required for them Explosives however were a different matter large quantities of many different types had been introduced into service, and it was necessary for these to be both stored and maintained Additional magazines and storehouses had to be built The Horsey Island Powder Works could no longer cope with maintenance and so in 1848 the beginnings of the depot laboratory were established

In 1901 buildings were erected for the examination and storage of mines However storage of mines at Priddy's Hard was soon discontinued—probably as a result of the 1903 Explosives Storage Committee's apprehension about Priddy Hard's holdings of cordite guncotton cartridges and shell By 1913 the 1 000 mines held locally each filled with a charge of 250 lbs of guncotton were all stored at the Gunwharf—a quarter of a million pounds (weight) of high explosive!

1914–1918

During the war greatly increased reserves of ammunition were held at Priddy's Hard and new explosives were introduced eg TNT Large new filling requirements arose and demands in general progressively increased As a result numerous additional storehouses laboratory rooms and workshops were designed and built

In 1918 construction began on a broad gauge rail link with Bedenham and Gosport's newer armament depots and the National railway system. By the end of the war the storage facilities at Priddy's Hard could hold a maximum of about 7 000 000 lbs (25 450 measurement tons) of explosive materials (shells bombs mines TNT etc) all packed into 80 acres (40 additional acres had been acquired). Surprisingly Portsmouth Naval Base and Gosport survived! Large as this explosives accommodation was it did not compare with Bedenham which at the time catered for 106 800 measurement tons of cartridges shell bombs and mines plus 12 000 measurement tons of cartridges in floating magazines.

1919–1981

In the inter war years of 1919–1938 despite the air power advocates the manned warship particularly the battleship was still regarded as the dominant sea weapon. This philosophy continued into the Second World War years until about 1942 when it became indisputably clear that the day of the battleship was over. In the 1939–1945 World War therefore the weapons and explosives used were similar to those of the 1914–1918 War—guns ammunition mines torpedoes depth charges bombs rockets etc—although these were much more sophisticated and advanced in design. The existing buildings at Priddy's Hard were suitable for storage and maintenance of most of these weapons and explosives but by 1939–40 explosives safety distances had tightened leaving no more space at Priddy's Hard for further development large-scale air raids were expected (and happened) and invasion fears were growing. To meet storage requirements of new production weapons and explosives and also to obtain dispersal against air raids it became necessary to requisition premises and open sub-depots further afield than Priddy's Hard eg at Hawthorn Tunnel Dover Reading Thatcham Southampton and Portland. Nevertheless the Priddy's Hard facilities played an important part in the local war effort particularly in the intense and involved preparation for Operations Neptune and Overlord in 1944.

In the post war years no new building was undertaken rather the reverse as various buildings were demolished. Since the late 1950's however two main features worthy of mention have occurred. The first was the transfer to Frater by 1960 of the workshops—guns small arms joiners painters hosemakers tinsmiths blacksmiths and M/T. The second was the gradual but complete rundown of explosives storage at Priddy's Hard by transfer of the explosives to Bedenham Dean Hill or elsewhere and the use of some of the resulting surplus storehouses for housing victualling stocks.

Priddy's Hard had a very illustrious career as an armaments depot but, mainly because of limited space and the proximity of local housing it became necessary to run down this establishment and transfer operations to other newer armament depots within the locality.

FRATER, ELSON AND BEDENHAM

These three areas form Portsmouth's present-day RN Armament Depot Gosport. Information on their past is however somewhat scanty and has been difficult to unearth.

The Frater and Elson areas were purchased in the mid-Nineteenth century and Fort Elson was constructed as part of an improvement in the Portsmouth Harbour defences. This fort has

Fig. Damage suffered in the Bedenham explosion in 1950

Fig. Damage resulting from the Bedenham explosion of 1950

long been abandoned although it still survives as a much overgrown ruin within the depot

The Bedenham area was purchased around 1908 and in 1910 work started on the construction of new magazines The building programme accelerated rapidly during the 1914 1918 war when more magazines and some laboratory facilities were acquired

In 1920 a mine depot was constructed at Frater This consisted of a self contained office storage mine assembly workshop and laboratory facilities Previously mines had been kept at the Gunwharf

Little else appears to have happened between the two World Wars except that in 1935 control of Frater passed from Mining Engineer Officers (Engineer Officers RN) to the Superintending Armament Supply Officer (SASO)

The Second World War again saw further development of this 475 acre complex with the construction of further depot facilities

In the long history of Portsmouth armament depots there had been no major disasters unfortunately this exemplary record was to be lost in 1950 when the Bedenham explosion occurred Various hypotheses were put forward as to the cause of the blast but none proven The site of the incident was Bedenham Pier where six lighters were being loaded with depth charges and 1 000 lb bombs Despite widespread structural damage to the Pier and surrounding buildings no life was lost although there were several injuries (*Figs 2 and 3*)

In 1959 Frater s mine depot was transferred to RNAD Milford Haven Following this move extensive alterations were carried out to the original buildings and Frater became the central workshop for numerous aspects of armament work The torpedo depot at Portsmouth Dockyard was closed and transferred to Frater along with all gunwork which had been carried out at Priddy s Hard Gunwharf

Elson which until 1962 had been used as a storage depot (like Bedenham) was completely transformed into a new depot for the servicing of the Navy s guided missiles This necessitated a widespread rebuilding programme which even now has not yet been completed

With the rise in importance of Frater Elson and Bedenham a gradual rundown of the Priddy s Hard facilities occurred and it will be closing shortly In 1977 the name for Portsmouth s armament depot was changed from RNAD Priddy s Hard to RNAD Gosport heralding the final phase in Priddy s Hard s long and illustrious history as an armament depot

The present roles of Frater Elson and Bedenham are as follows

Frater	Main non-explosive workshop area general workshop activities Facilities for overhauling and repairing of torpedoes.
Elson	Guided missile processing area
Bedenham	Explosive storage area (*Fig 4*)

Fig 4 The main gate to RNAD Gosport.

DEAN HILL

In this brief historical account a mention should be made of RNAD Dean Hill an accessory explosive storage area Located in the countryside between Romsey and Salisbury it was constructed during the Second World War and consists of numerous tunnels dug out of the side of Dean Hill The reason for its construction was two fold first, to provide extra room for the storage of explosives and secondly to provide a more secure area from the effects of air raids It is still used today and the tunnels are constantly being repaired and modernised

CONCLUSION

This article has been focused on the history of Portsmouth s various armament depots and how they developed from their origins in the Tower of London

What of the future?

Priddy s Hard is now on the point of closure all its roles having been transferred to the Frater Bedenham and Elson Complex It is likely that the role of these areas will not change in the near future As new weapons become operational and old systems obsolete various buildings will have to be adapted to store/maintain the latest armaments Broadly speaking Elson will remain the guided missile area, Bedenham the storage area and Frater will concern itself with torpedo maintenance and the provision of general workshop facilities

J Roy Nav Med Serv 1987 74 24–32

A Nutritional Analysis of Food provided to Royal Naval Personnel at Sea

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Abstract

The aim of this study was to determine the nutritional content of the foods provided to and the confectionery purchased by personnel serving at sea in British warships. Data were collected from the stores accounts of six ships over a period of 37 354 man victualling days. Analysis was carried out at the Nuffield Laboratories of Comparative Medicine. The food from the ships galleys provided mean daily intakes of 3 750 Kcals of which 42% were derived from fats (17% from saturated fats) and 9% from added sugars. In taking account of confectionery purchased from NAAFI sources the total energy intake was raised to 4 200 Kcals of which 40% were derived from fats (15% saturated fats) and 12% from added sugars. The results do not compare favourably with the recommendations of the reports of expert committees.

INTRODUCTION

NUTRITION has been recognised as an essential element in the health and well-being of those who serve at sea since the time of James Lind's discovery of a cure for scurvy in the seventeenth century. With the increasing amount of evidence of a relationship between diet and disease now being published, the emphasis on the role of good nutrition at sea must surely be as great today as it was for the contemporaries of Lind. Whilst at sea the sailor is dependent upon the Royal Navy to provide all his food. Food at sea takes on a vital role other than as a source of nutrients to maintain fitness, in that it appears to play a major role in the psycho social wellbeing of the sailor. Thus it is important that the food served should be varied and appetising as well as being nutritionally adequate. Male personnel serving in the Royal Navy today may spend up to sixty per cent of their service at sea. The age distribution of the Royal Navy demonstrates a relatively young population being of late teens or early twenties. In contrast to his forerunners in the days of sail and steam the sailor of today carries out few strenuous tasks in the performance of his routine daily work.

Much concern has been expressed in reports by expert committees that the dietary intakes of the British people are detrimental to health. The report of the National Advisory Council on Nutrition Education (NACNE)[1] reviewed four publications by the Department of Health and Social Security, three by the Royal College of Physicians and one by the World Health Organisation in addition to over 90 papers in the scientific literature. The NACNE report made recommendations for specific changes in the quantities of fats, fibre, sugar and salt in the average British diet. Similar recommendations to those of the NACNE report were made in the report of the Board of Science and Education of the British Medical Association—Diet, Nutrition and Health.[2] The report of the Chief Medical Officer's committee on medical aspects of food policy (COMA) on Diet and Cardiovascular disease[3] made specific quantitative recommendations for the reduction of fats and stated that sugar consumption should be re

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dneed because of its relationship to dental caries

The literature reveals little about the nutritional content of food provided at sea. Southgate and Shirling[4,5] surveyed the diet of submariners and concluded that the energy derived from the food exceeded the average energy expenditure by an amount that was statistically significant. Thom and Morris[6] reviewed dietary matters of the Royal Navy proposing that "maritime malnutrition still occurred in the 1970's

More recently Gilbert and Brooks[7] analysed the catering stores accounts detailing all issues of foods in three Royal Naval submarines. They reported high energy intakes of 4 431 Kcals per man per day, 45% of which were derived from fat and 15% from sugars. Had their study included confectionery and carbonated drinks the absolute energy intake and fat and sugar levels would certainly have been greater. Comparing the nutritional content of the food provided in these three submarines with the recommendations of the NACNE report they concluded that the food consumed would contribute in the short term to loss of overall fitness and predispose in the long term to disease.

Evidence of diet related ill-health may be found in the literature. In a survey of 10 000 sailors Mackay[8] showed that the contemporary naval rating was seven kilograms heavier than his predecessor of 1950. Khosla and Lowe[9] put forward that Mackay's figures were likely to represent a true increase in the fatness of sailors. Watt [8] suggested that the incidence of peptic ulcer in the Navy was more than three times that in a comparable National Health Service male population. Amongst factors cited to account for this he put forward a diet rich in refined carbohydrates and lack of exercise. In the same report Watt cited Forrest who had demonstrated that the consumption of confectionery in ships was three times the national average. Thom[11] suggested that obesity and constipation were occupational hazards in nuclear submarines.

AIM

The aim of this study was to determine the nutritional value of foodstuffs offered from the Royal Naval sources to servicemen in a sample of Her Majesty's Ships to assess whether they were in line with recent published guidelines. The hypothesis tested was that the diet provided to men at sea contained levels of sugars and fats which were greater than and a level of fibre which was less than the NACNE and COMA recommendations.

METHODOLOGY

The Study Population

The sampling frame was constructed to include all ships and submarines in commission whose complements (number of men borne) were greater than one hundred men. In the second stage sample the complements of each individual unit were rounded up or down to the nearest fifty men and a sample of ships was selected randomly on the basis of probability proportional to complement. The sample drawn comprised one aircraft carrier, three destroyers and two frigates (2 311 men in toto) (*Table 1*).

Data Collection

Each unit sampled supplied copies of victualling stores accounts detailing daily issues of food to the galleys and dining halls for a period of fourteen consecutive days at sea. To enable an estimate of total dietary intake to be made a separate limited analysis of confectionery items sold by NAAFI canteens in the sample of ships

Table 1 The sample of ships, their area of deployment, the numbers of men borne and the numbers of food items included in the analysis

SHIP	NAME	MEN BORNE	AREA	FOOD ITEMS
1	HMS Manchester	301	Gulf	155
2	HMS Birmingham	295	S Atlantic	160
3	HMS Southampton	291	S Atlantic	161
4	HMS Battleaxe	243	Indian Ocean	162
5	HMS Arrow	207	Caribbean	124
6	HMS Illustrious	974	N Atlantic	174
	Total number of men	2 311		

Table 2 Analysis of daily food issues to ships' dining halls and galleys (Expressed as units per man per day)

SHIP	1	2	3	4	5	6	SAMPLE
Energy (Kcals)	4 044	4 473	4 151	4 307	3 433	3 258	3 754
Carbohydrate (g)	511	609	474	505	372	331	430
Added Sugars (g)	76	86	91	76	83	92	87
Total Sugars (g)	118	147	144	122	127	145	137
Dietary Fibre (g)	34	39	31	29	25	27	30
Protein (g)	148	156	150	153	135	137	144
Fat (g)	171	173	197	200	166	163	174
Saturated Fat (g)	66	72	82	70	63	61	67
Sodium (mg)	4 569	4 583	4 344	5 069	5 439	4 545	4 663
Calcium (mg)	1 277	1 404	1 568	1 157	1 478	1 278	1 336
Iron (mg)	23	27	23	28	19	22	23
Zinc (mg)	20	20	20	22	18	17	19
Vitamin A (RE)	2 737	3 783	2 831	4 377	2 112	2 835	3 040
Vitamin D (ug)	6	7	13	7	5	6	7
Thiamin (mg)	2	2	2	2	1	1	2
Riboflavin (mg)	2	2	3	2	2	2	2
Niacin (mg)	60	67	59	66	60	67	64
Vitamin C (mg)	131	145	151	203	72	80	116
Vitamin E (mg)	8	10	8	11	7	6	8
Vitamin B6 (mg)	3	3	2	3	1	2	2
Vitamin B12 (ug)	11	16	12	20	10	14	14
Folic Acid (or (ug)	317	382	354	356	253	339	338
Pantothenic Acid (mg)	7	8	8	8	5	7	7
Cholesterol (mg)	618	625	1 111	831	728	812	795

was also made. Data were collected of the product name, weight/volume and average daily sale of the six most popular chocolate bars, non-chocolate confectionery items and biscuits and crisps and the three most popular carbonated drinks, beers and lagers.

Data Analysis

Allowances were made from raw (as purchased) to net weights (edible portion) using the McCance and Widdowson (1978) factor for appropriate foods. Issues of cooking oil were discounted due to difficulties encountered in estimating its rate of wastage. Instead methods of cooking were taken into account to allow for oil. For example proportions of potatoes were analysed as chipped and fried, roast or boiled.

Food items were coded by a dietician for each individual ship for input into the computer at the Nuffield Laboratories of Comparative Medicine, Institute of Zoology (NLCM). The NLCM database on food composition contains information on approximately 1 500 foods of which 970 were derived from McCance and Widdowson (1978), others from a variety of sources including United States Department of Agriculture,[2] MAFF[13] and their own analyses. The output from the computer listed units per man per day for total energy and 35 nutrients.

RESULTS

The results are given for each individual ship and as a sample mean that is weighted in proportion to the number of men victualled in each sampled unit. The results are expressed as a ratio estimate of intake per man per day for the fourteen day period, where the ratio estimate is

$$R = \frac{Y}{X}$$

Y is the mean daily intake of the nutrient for ship and X is the complement. Thus the sample mean is

Table 3 Per cent contributors to energy and P/S ratio of foods provided to galleys and dining halls

SHIP	1	2	3	4	5	6	MEAN
ENERGY % of							
Fat	38 0	34 6	42 8	41 6	43 9	45 0	41 7
Protein	14 6	14 1	14 5	14 2	15 6	16 5	15 4
Carbohydrate	47 4	51 1	42 7	44 0	40 3	38 1	43 0
Added Sugar	7 1	7 2	6 2	6 6	8 3	10 3	8 7
PUFA	2 7	3 0	2 9	3 6	5 5	4 1	3 7
SFA	14 6	14 5	17 7	14 6	16 6	17 0	16 2
Trans Fat	1 2	1 1	1 2	0 8	1 1	1 2	1 1
P/S Ratio	0 18	0 20	0 17	0 25	0 32	0 24	0 23

Table 4 Analysis of estimated daily sales of confectionery biscuits and carbonated drinks from NAAFI canteens (Expressed as per man per day)

SHIP	1	2	3	4	5	6	MEAN
Energy (Kcals)	503	475	373	433	520	429	446
Added Sugars (g)	62 0	64 6	44 2	38 2	56 6	49 0	50 1
Total Sugars (g)	70 5	73 6	47 8	48 1	60 7	66 4	58 8
Carbohydrate	74 7	77 8	56 7	56 0	73 6	63 5	66 0
Fat (g)	13 2	9 1	12 0	13 4	19 0	12 9	12 9
Alcohol (g)	12 4	13 2	5 8	12 4	7 7	8 6	9 5

$$\hat{R} = \frac{\Sigma Y_i}{\Sigma X}$$

The individual results are presented without allowance for wastage on cooking utensils serving dishes and plates in *Tables 2 5 Table 6* demonstrates the effects of various wastage ratios applied to the gross figures

Energy

Estimates of daily energy intake derived from foods provided from the galley varied from 3,258 Kcals (13 64 MJ) for Ship 6 to 4 473 Kcals (18 72 MJ) for Ship 2 Mean daily intake for the sample was 3 754 Kcals (15 71 MJ)

Estimated daily energy derived from the purchase of confectionery and drinks from the NAAFI canteen vary from 373 Kcals (1 56 MJ) to 520 Kcals (2 18 MJ) The weighted mean energy intake derived from confectionery for the sample was 446 Kcals (1 87 MJ)

Carbohydrate

Estimated mean daily carbohydrate intake from galley foods was 430 grams per day (gpd) Sixty eight gpd were available from confection ery sources giving n total intake of carbohy drates of 496 gpd

Sugars

Estimated daily consumption of total sugars varied from 118 grams for Ship 1 to 145 grams for Ship 6 Of this total intake 76 grams and 92 grams respectively were provided by added sugars (glucose, fructose and sucrose) Esti mated daily mean intakes for the sample were 137 grams of total sugars of which 87 grams were added sugars

Estimated sugars from NAAFI sales amounted to 59 grams per day giving an overall daily total sugars intake of 196 grams (71 kilos per head per year) Added sugars from this source amounted to a mean of 50 gpd which when added to the added sugars in foods amounted to 138 gpd (50 kilos per head per year)

Fibre

Estimated mean daily fibre intakes varied from 25 gpd for Ship 5 to 39 gpd for Ship 2 The estimated weighted sample mean was 30 gpd for food provided from galley sources A small quantity of fibre was provided from confection

Table 5 Combined foods and confectionary—mean daily intakes

SHIP	1	2	3	4	5	6	MEAN
Energy (Kcals)	4 546	4 947	4 524	4 740	3 835	3 686	4 199
Added Sugars (g)	138	153	135	113	140	140	138
Total Sugars (g)	186	221	192	166	188	200	196
Carbohydrate (g)	566	687	531	561	446	395	496
Fat (g)	184	182	209	213	185	176	187
Protein (g)	152	160	152	156	138	148	150
Fibre (g)	34	40	33	31	27	32	33
Energy % from							
Added Sugar	12	12	12	10	12	16	12
Total Sugar	16	17	17	14	19	21	18
Carbohydrate	51	54	47	47	45	37	44
Protein	13	13	13	13	14	16	14
Fat	36	33	41	40	42	45	40

Table 6 Illustration of the effect on the Results for Galley Food of the application of different scales of Wastage

NUTRIENT	Gross	Allowance for Wastage 5%	10%	15%	20%
Energy (Kcals)	3 753	3 547	3 361	3 174	2 987
Added Sugars (g)	87	82	78	73	69
Total Sugars (g)	137	133	126	118	112
Carbohydrate (g)	430	406	384	363	342
Fat (g)	174	164	156	147	138
Protein (g)	144	136	129	122	114
Fibre (g)	30	28	27	25	24

ery (biscuits and crisps) to raise the gross daily fibre intake to 33 grams

Fat

Estimated mean daily fat intakes varied from a low of 163 g for Ship 6 to 200 g for Ship 4 The weighted mean estimate for the sample was 174 grams per day of which 67 gpd were contributed by saturated fatty acids (SFAs)

The mean ratio of polyunsaturated fatty acids (PUFAs) to saturated and trans fatty acids in food from the galley was 0 23

Sources of Energy—Sample Means

—Foods provided to galleys and dining halls Forty one point seven per cent of food energy was derived from fats (16 2% from SFAs) 43% from carbohydrates and 15 4% from protein Added sugars provided 8 7% and total sugars 13 7% of total energy

—Total Intakes (foods and NAAFI confectionery)

Total sugars provided 18% of the total energy Most of this was added sugar which provided 12% of total energy Alcohol sales contributed 1 6% of energy whereas fat carbohydrate and protein provided 40 44 and 14% respectively

Wastage

The results have been presented as gross figures having made no allowance for plate and galley wastage *Table 6* illustrates the effects of applying wastage rates of 5 10 15 and 20% to the results for galley food To achieve the DHSS recommendation of 2 900 Kcals daily a wastage rate of 20% would need to occur

Table 7 allows comparison of the gross results with both NACNE and COMA targets and DHSS Recommended daily amounts of food energy and nutrients (RDA s) [14] Except for fibre

Table 7 Comparison of nutrient values from analysis of the galley foods and combined foods and collection diary (total intakes) with the recommendations of NACNE (short term goals) COMA and DHSS RDAs

NUTRIENT	Foods	Total intake	NACNE	COMA	DHSS RDAs
Energy (Kcals)	3 754	4 218			2 900*
Fibre (g)	30	33	25		
Added sugars (kg/year)	32	50	20		
Energy % from					
Added Sugars	9	12	12		
Total Sugars	14	18			
Carbohydrate	44	44	55		
Protein	15	14	11		10
Fat	42	40	34	<35	
Saturated Fat	16	15	10		
Sat & Trans Fat	17	15		14	
P/S Ratio	23	25	36	45	

*Recommendation for moderately active males aged 18–34 years (DHSS 1979)

(see below) the study results were all outside recommended guidelines The COMA report recommended that energy derived from fat should not exceed 35% of total energy and the P/S ratio should approach 0 45 Fats in the total diet (galley and NAAFI) provided 40% of energy and the estimated mean P/S ratio was 0 25

DISCUSSION

Methodology

All nutritional surveys are subject to many errors which may not easily be controlled The use of either a dietary diary or weighed-meals analysis would not have been possible due to difficulties involved in surveys of this type Dietary diaries require much dedication on the part of the subjects towards the meticulous recording of all foods eaten and rely on estimation of quantities The fact the subject is aware of having to record his intake for analysis may well have a significant bearing upon his food choice This is even a greater factor in weighed meals analysis where at each meal food from the plate is weighed piece-meal and then returned for the subjects consumption In weighed meals analysis it is not possible to survey a large sample due to laborious involvement of manpower The analysis of foods made available for consumption as performed in this study allow large samples to be studied and reflects more the policies adopted by those responsible for providing the food Results obtained from studies such as this cannot relate to the diet of any one individual but indicate patterns of consumption and the availability of food at a population level

Sampling

Two different samples were involved in the study One the selection of ships and the other the selection of the 14 day study period The sample of ships was selected randomly and if large enough may well have been representative of the Fleet However three ships having been selected in tropical waters may have an effect of underestimating energy intakes and similarly ships in distant waters may suffer restriction in numbers of foods available The selection of Ship 6 (HMS Illustrious) with such a large ship's company will have had a marked effect upon the sample mean She was the only ship of that size sampled and it is thus not possible to determine how representative she is of large ships in the Royal Navy It would be prudent to accept the results as they stand rather than as a sample mean being representative of any larger population

The selection of the period of food issues to be sampled was left to the individual ships the ships having been requested to select a period representative of their normal operating routine As only single 14 day periods were taken for each ship no estimate of the degree with

which these periods are representative can be made As these periods were selected on a historical basis of foods already issued it is not possible that any deliberate bias could have been introduced

Reliability of Data

The data were abstracted from book keeping records involving the expenditure of public monies. Due to strict regulations and auditing procedures it is doubtful that any error would have been present It was obvious from study of the victualling records that food is issued on a daily basis only as required The only item not issued on a daily basis was salt, the gross figures of which were reduced by 90% to allow for wastage in cooking water If residual stocks were to be a source of error it is likely that over a fourteen day period they would be self correcting No account was made for the possibility of individuals eating their own foodstuffs brought on board from ashore as this practice barely ever occurs

The confectionery data were provided by estimate of daily sales in NAAFI canteens Daily confectionery sales are subject to variation on account of depletion of stock on long voyages The analysis of results indicates similar trends in all ships and it is recommended that a full study of confectionery sales be carried out in the future Had the confectionery analysis not been limited it is anticipated that the absolute amounts of fats sugars and alcohol would be higher than as reported in this study

Sources of Error in Data Analysis

A shortcoming of all nutritional analyses performed from a standard database is that the database is not necessarily representative of the actual food items but of samples of food used in the original biochemical analysis Thus for example the fat levels of the meals consumed on board the ships during the survey period may differ from those in the database Sugar levels would not have been subject to such error as most of the sugar was issued as granulated sugar (pure sucrose) which was then incorporated into recipes on board becoming hidden sugar

Estimates of wastage have been very difficult to make In food preparation standard percentages were deducted for fresh vegetables and fruit By inspection both plate and galley wastage appeared to be very low and the author is inclined to agree with estimates of less than 5% proposed by those directly involved with naval catering. Anecdotal evidence from the Supply Officers responsible for catering on board the sampled ships suggests that total wastage is very low and does not exceed 5%. The Ministry of Agriculture Fisheries and Food routinely allow for 10% wastage in the National Food Survey Some authorities in the Armed Services suggest wastage may be as high as 15 or even 20% However it is noted that Gilbert and Brooks[3] followed the allowance deducted by Southgate and Shirling[5] in surveys of submariners intakes The application of any wastage rate to the results of the study was not thought to be appropriate due to the inaccuracies involved and the fact that usually more foods rich in fat are left on plates rather than those rich in sugar The application of an overall wastage ratio makes no difference to the percentage contribution of food items to energy

The Food Eaten in HM Ships

By comparison with recommended guidelines and diets of other groups the diet provided at sea is excessively high in calories provided by excesses of fats and sugars Even in the one ship whose energy intake approached the recommended level the composition of the diet was imbalanced as 45% of energy was derived from fat

The high intakes of food would support the hypothesis that the consumption of good food at sea was an important factor in the socio-psychological aspects of life of the sailor as it must be doubted that he requires a mean intake of around 3 700 Kcals (similar to that recommended by the DHSS[14] for the very active such as army recruits and building workers) In considering the energy requirement of the sailor... the technological and electronic evolution of warship design and operation means that the demands made upon the sailor are becoming increasingly mental/intellectual and much less physical However at times there is occasion for men to work in a physically hostile environment on the upper decks in adverse weather when a need for plenty of hot high calorie foods may arise

The study hypothesis that sugar and fat consumption was in excess of NACNE and COMA guidelines is supported by these results However the hypothesis that fibre consumption was below the recommendation was not substantiated as fibre availability surpassed the NACNE target However further consideration of fibre content in relationship to the total diet may support the study hypothesis The NACNE

target was determined by *weight* of fibre (it having no nutritive energy value) in an average diet of approximately 2 500 Kcals. Thus a diet of greater proportions will accordingly require more fibre. It is doubtful that the current mean intake of 30 grams per day is sufficient for the demonstrated food loads of 3 750 Kcals.

As the results presented for each ship are a mean for that ship the diet of each individual will be distributed about that mean. The diet of each individual can only be determined by methods allowing individual analysis such as diet records or weighed meals analysis. However some individuals will be taking a low volume diet (small-eaters) concern should be expressed for this group as many may not be obtaining adequate levels of vitamins and micronutrients. In consideration of vitamins and micronutrients all except for vitamin E were present in adequate quantities but when studied in the light of those consuming a calorie intake in line with the RDA, become borderline.

It is the job of the caterer to provide a varied diet within strict financial constraints. That he achieves this is not disputed. He has received minimal training in nutrition. The food he issues will reflect the demand by those who prepare the food and those who eat it, only to be restricted at times by the need to balance expenditure and income. The cook will provide such foods that his training, his recipe manuals and his experience dictate. If he has not received adequate training in nutrition and his recipe manual reflects outdated principles there is little chance that the dietary intakes of sailors will become relevant to their modern occupations.

Implications

The effect that this type of diet may have on the efficiency of the Royal Navy could be serious. The excess energy intake provided by the large amounts of fat and sugar will be stored as body fat leading to a heavy, large-volume sailor who is unable to react quickly and move himself rapidly. Speculation as to his physiological state in the hours after eating this calorie-rich food may suggest sluggishness and sleepiness. The medium term effects of the diet will be seen in a wide prevalence of dental caries and premature failure of existing dental restorations. Alexander[19] reported an increase in caries status of two decayed, missing or filled teeth (DMFT index) in a sample of twenty-five year old naval personnel since their entry into the service some eight years before. What amounted to a 20% increase in the number of apparently diseased teeth may appear surprising in a late teens/early twenties age group. This incidence of dental disease itself decreases the efficiency of the Royal Navy through time lost from work travelling to and from dental clinics and undergoing expensive restorative treatments. The risk of dental pain occuring at sea will also be greater. The longer-term effects of the diet are rarely seen in Reports of the Health of the Royal Navy[16] as the symptoms of most diet related diseases do not become apparent until middle age at which time in life the majority of sailors have become civilians. A similar high calorie high-saturated fat diet was alluded to in the report of autopsies on 300 American casualties during the Korean war by Enos Holmes and Beyer.[17] They suggested that atherosclerosis was prevalent in young people. One out of every ten of these healthy young men had a section of his coronary artery blocked by more than 50% and one in four had a 20% blockage. The authors concluded that diet must be one of the contributing factors.

CONCLUSIONS

This study has demonstrated that in a sample of HM Ships the nutritional content of the food provided compares unfavourably with the dietary guidelines recommended by expert committees. The diet contains high levels of fats and sugars. The calorie intakes are high in relation to tasks performed by the young adult serviceman at sea. Further research is required to determine how great the effect of this type of feeding may be on morale and efficiency. Any action taken to bring about patterns of catering which follow NACNE and COMA guidelines will require a fully coordinated effort by all those involved in the supply and storage of provisions, the menu planning and preparation of foods, the health education of service personnel and the setting and maintaining of physical fitness levels. Many District Health Authorities have tackled similar problems by the implementation of food health policies.

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Exertional Hyperpyrexia: Case report and review of pathophysiological mechanisms

M R Jarmulowicz and J D Buchanan

INTRODUCTION

Heat stroke among military personnel in combat has been recognized and recorded as far back as 24 BC [1] More importantly heat stroke whilst under training has also become a problem [2 3] Most healthy adults who are incapacitated by heat stroke do not suffer serious tissue damage however heat illness may rapidly progress to a disastrous situation with widespread tissue damage and sudden death without correct and prompt treatment

This paper presents a fatal case of exertional hyperpyrexia in a diver under training with a discussion of the pathophysiological mechanisms of heat induced illness

CASE REPORT

A 17-year-old trainee diver was on the second day of a two day diving aptitude course the aims of which are to test prospective divers for the following three qualities

1 Physiological adaptability mainly the ability to tolerate the pressure changes involved in diving
2 Psychological suitability for working in the difficult environments encountered in diving.
3 Physical fitness and endurance

At 08 30 hours on 15 July 1986 with the temperature around 18°C and a high humidity trainees conducted approximately 20 minutes of physical training exercises dressed in a PT vest trousers and boots Following this they changed into a standard Royal Navy Dry Diving suit which consists of a black all in one rubber suit leaving only the hands and head exposed under which was worn a woollen all in one jump suit. They were then required to run through deep mud on a 0 8 mile course which they were expected to complete in approximately 15 minutes. The majority of the course consisted of ankle deep mud with a 50 metre basin of knee deep mud just before the end of the course By the start of the run (at approx 09 00 hrs) the morning mist had cleared and a light sea breeze was present

A trainee who was in the leading group collapsed with breathing difficulties 75 metres from the end of the course Two others also collapsed within a short time First aid was given This consisted of moving the men into the shade removing their rubber diving suits and soaking them with cold water however the first suffered a cardio respiratory arrest from which he could not be resuscitated His rectal temperature recorded on admission to hospital was 42°C The other two made full recoveries although one required intensive hospital care

At post mortem the major finding was widespread intrapulmonary haemorrhage involving all but a small part of both upper lobes and the upper part of the left lower lobe (*Fig 1*) The extent of the haemorrhage is reflected in the lung weights left lung 620 gms right 770 gms (normal weights are 375 and 450 gms respectively). Histological sections from many organs particularly the lungs and kidneys showed diffuse intravascular coagulation in small vessels (*Fig 2*) Post-mortem analysis of

Surgeon Lieutenant Jarmulowicz is on the Emergency List Surgeon Commander Buchanan is Consultant Adviser in Pathology to MDG(N) and is serving at RNH Haslar

blood showed the following Haemoglobin—20 g/dl Haematocrit—0 67 Fibrin Degradation Products—1 in 2,160 PTTK—>180 secs PT>100 secs Thromboplastin Time >120 secs, Platelet count $<20\times10^9$/litre These results despite being taken on post-mortem blood are diagnostic of Disseminated Intravascular Coagulation together with marked dehydration

Fig 1 Cut surface of lung showing extensive haemorrhage

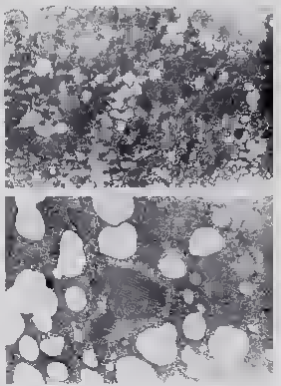

Fig 2 MSB stained sections of lung, ×30 and ×80 showing extensive intrapulmonary haemorrhage with blood vessel containing fibrin thrombus

DISCUSSION

It has been recognized since before the second World War[6] that the effects of excessive heat present in one of two distinct forms

1 *Heat Exhaustion* This usually takes several days to develop in the unacclimatized person in a hot environment and is due to salt depletion and dehydration Rectal temperature is below 42°C

2 *Heat Stroke* (Hyperpyrexia) This most commonly occurs in the very young and elderly and is due to a temporary failure of the heat regulating mechanism Rectal temperature usually rises above 41°C and there is anhidrosis plus profound CNS disturbances

The above classification was based on civilians exposed to excessive heat and it has been recognized that there is a third important variant of the classic hyperpyrexia. Exertional hyperpyrexia[7] is important, not only in that it lacks the anhidrosis present in the classic form but has a high incidence of rhabdomyolysis leading to a higher morbidity and mortality It is this variant that particularly is relevant to the Service environment

Exertional hyperpyrexia is a leading cause of death among American athletes second only to head and spinal injuries[8] and it is not difficult to find reported cases of exertional hyperpyrexia in military personnel under training In 1985 a company strength Australian Army exercise involving an assault on a hill resulted in 22 men being hospitalized with hyperpyrexia.[9] In another exercise in Equador involving only a 7 km run 20 out of 216 Naval cadets suffered exertional hyperpyrexia with three fatalities.[3] More importantly although exer-

tional hyperpyrexia is more prevalent in hot climates it may also occur readily in temperate climates [4 9] During the period July 1981 to September 1984 6 6% of all admissions (n=605) to the intensive care unit of the Cambridge Military Hospital Aldershot were for heat related illness [10]

PATHOGENESIS

Historically there are two opposing views regarding the pathogenesis of heat stroke The original theory[2] is that heat induces direct thermal injury of the target tissue This has led to the concept of the Critical thermal maximum [11] Experiments have demonstrated that this is not a fixed temperature but varies not only between individuals and different tissues but also with time of exposure to a particular temperature [12 13 14] This is further borne out by the finding of body temperatures in excess of 42°C in marathon runners who sustained no ill effects,[15] which strongly suggests that acclimatization is protective

The other view[16] stresses that circulatory failure is the main factor As in most medical controversies both arguments contain elements of the truth In an experiment where rats were exercised to exhaustion and/or exposed to high ambient temperatures [17] it was shown that hyperpyrexia was the predominant factor in mortality However at the lower end of the thermal load work plus the same degree of hyperpyrexia was more lethal than hyperpyrexia alone In support of the circulatory shock hypothesis the running rats prior to collapsing of exhaustion displayed a dramatic drop in tail temperature This suggested a peripheral vasoconstriction which further added to the problem of developing hyperpyrexia by reducing the rate of heat loss Peripheral vasoconstriction is also recognized in cases of human exertional hyperpyrexia [4]

The exact pattern of tissue damage will depend on whether the predominant injury is widespread disruption of cellular membranes enzyme systems and proteins of the coagulation mechanism or whether anoxia due to the hypotension associated with the hyperpyrexia is the main factor

During severe exercise a profound reduction in plasma volume can occur well in excess of that which can be attributed to fluid loss by sweating [18] It has been suggested that this is due to metabolism of muscle glycogen to small osmotically active intermediates which shift water from the plasma into muscle cells [19] Also the combination of peripheral vasodilation required for heat loss plus the muscular vasodilation required for work leads to a large increase in vascular capacitance During acclimatization there is an increase in the blood volume which counteracts the exercise induced fall [18,20]

Coagulation abnormalities

The autopsy findings of exertional hyperpyrexia are well described [6 7] and consist of widespread pulmonary haemorrhages plus haemorrhages in many other organs These are attributed to Disseminated Intravascular Coagulation (DIC)

Changes in coagulation can be found in very mild heat exposure In a case report of a 29 year-old army sergeant who collapsed 200 m from the end of a 15 km run with a rectal temperature of 39 2°C [22] the authors describe a complex sequence of initial activation of fibrinolysis lasting 3–4 hours followed by depression of fibrinolysis and depression of hepatic protein synthesis leading to a decrease in coagulation factor production (the evidence of hepatic damage was suggested by increased bilirubin and liver enzymes) In addition there was a severe thrombocytopenia maximal at 48 hrs for which there was no obvious explanation

In a more recent report concerning 55 case studies of heat stroke [3] thrombocytopenia was confirmed as a common finding The evidence supported liver cell damage as a contributing factor in the breakdown of haemostasis The series included 17 cases of documented DIC (thrombocytopenia increased fibrin degradation products hypofibrinogenaemia and a prolonged prothrombin time) These patients had a significantly higher mortality (65%) than those without DIC (13%) It was suggested that the trigger mechanism for the DIC was activation of the extrinsic coagulation pathway by tissue damage In exertional hyperpyrexia rhabdomyolysis may also be an important trigger It is important to be aware that DIC can develop up to 72 hours after presentation of heat stroke though in these late cases the DIC is mild and often requires no active treatment

Biochemical changes

In South African mines and the Israeli army heat stroke is only diagnosed in the presence of hyperpyrexia if the serum liver enzymes are elevated.[24] In this series of patients the serum transaminases and LDH were significantly elevated in all 75 patients with heat stroke either

on admission or within 24 hours and continued to rise till 48 hrs The levels returned to normal in 12 to 14 days whereas 9 patients admitted with an initial diagnosis of heat stroke but subsequently found to have an infective cause for their pyrexia were found to have normal liver enzyme levels The degree of elevation of the serum enzyme levels was found to be a reliable index of severity of tissue damage In 15 patients with transaminase levels >1 000 iu renal hepatic and cerebral damage was severe with a high mortality or permanent sequelae whereas in 20 patients with a level of <1 000 iu the tissue injury was usually mild and reversible with only 1 death

It is important to recognize that enzyme release and rhabdomyolysis (seen as an increase in CK levels) can be produced by exercise alone and is related to the degree of training and activity undertaken eg enzyme elevation in trained marathon runners with a heavier exertion was lower than that found in untrained marching men [25]

Hypokalaemia is widely reported during periods of heat stress However in exertional hyperpyrexia hyperkalaemia is a more common finding probably as a result of the associated rhabdomyolysis.[26]

Hypocalcaemia may also be seen for two reasons First calcium is deposited in injured muscle as calcium carbonate and phosphate Secondly rhabdomyolysis causes a release of phosphate which because of its inverse relationship with calcium results in a fall in its serum concentration [27]

Hypoglycaemia as low as 1 mmol/l has been recorded [28] and may be the cause of CNS disturbance

Rhabdomyolysis and renal failure

The pathogenesis of Rhabdomyolysis is obscure but can occur without any hyperpyrexia and most commonly occurs in the first few days of training. One suggested mechanism is ischaemia of muscles caused by sustained exercise which is aggravated by potassium deficiency [29] In a prospective study in a marine training camp [30] recruits complaining of the symptoms of rhabdomyolysis (local pain swelling and limitation of muscular activity) had muscle biopsies done The histological appearances were identical to those found in heat stroke suggesting that both are the result of similar mechanisms [31]

Acute renal failure is a severe complication of exertional hyperpyrexia occurring in approximately 30% of victims [32] with mild proteinuria being found in virtually all heat stroke patients Rhabdomyolysis contributes to renal tubular injury in several ways. First such patients are already dehydrated and further loss of fluid by sequestration into injured skeletal muscle aggravates an already compromised renal blood flow Secondly muscle injury results in myoglobinuria and hyperuricaemia with the excretion of large quantities of uric acid into an already concentrated acid urine Myoglobin itself may be nephrotoxic [3] and uric acid nephropathy can also occur [31] In addition there is a correlation between glomerular injury and DIC [34] Early intervention to establish an adequate urine output is important

Hyperpyrexic victims are either comatose or profoundly disorientated on presentation This should rapidly reverse after reduction of the core temperature to normal Cerebral oedema, petechial haemorrhages and a marked disruption of cerebellar Purkinje cells can routinely be demonstrated at post-mortem in lethal cases.[35] Following heat stroke the majority of patients make a full recovery but a measurable decline in intellectual function ranging from mild confusion to a frank dementia has been documented in a few patients [4,35]

Acclimatization

In a detailed prospective study of both heat exhaustion and heat stroke at the marine recruit depot South Carolina [36] it is interesting to note that of 13 cases of heat stroke (from 7 000 recruits) the majority were unacclimatized

The mechanism whereby acclimatization protects against the development of heat illness is beginning to be unravelled. There is evidence for the existence of a series of highly conserved proteins (heat shock proteins (hsps)) that are present in both animal and plant kingdoms and are rapidly synthesized in response to exposure to an above normal temperature.[37] The most highly conserved of these proteins has been sequenced in several species and has shown a 50% homology between those of man and E coli with a central peptide sequence of 45 amino acids containing only four differences

The exact function of these proteins is uncertain but there is evidence demonstrating a role in protecting the cell against thermal injury In a series of experiments groups of cells and organisms were exposed to an extreme environmental temperature and the kinetics of lethality were measured Another identical set was incubated at a moderately elevated tempera-

ture thereby inducing synthesis of hsps and then exposed to the same extreme temperature as the first set. A dramatic increase in survival was observed in the second set. Furthermore natural degradation of the hsps when the heat pretreated cells were returned to normal temperatures coincided with the decay of thermotolerance. Finally, mutants unable to synthesize hsps were unable to acquire thermotolerance whereas mutants which could survive high temperatures without conditioning pretreatments produced high levels of hsps. It is also of interest that hsps can be induced by other agents, including ethanol.

ACKNOWLEDGEMENTS

We wish to thank Mr Glanville, Her Majesty's Coroner for the City of Portsmouth for permission to use this case and Mr T. Over for the illustrations.

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Management of Heat Stroke

S P L Travis MB MRCP

INTRODUCTION

Heat stroke describes a clinical syndrome produced by overheating of the body core The condition has been recognised since biblical times[1] and was the likely cause of death of Pheidippides who brought the news of the Athenian victory over the Persians at Marathon in 450 BC It can be produced in normal people by arduous exercise in a humid environment [1] It may also occur in a hot dry environment if sweating is limited by dehydration [4] drugs[5] or disease [6] The outcome depends not only on the degree but also the duration of hyperthermia [7] Heat stroke is a medical emergency that demands urgent diagnosis and treatment [8]

DIAGNOSIS

The cardinal features of heat stroke are

1. Disturbance of consciousness
2. Rectal temperature >40°C

A hot dry skin due to cessation of sweating is common [8] but by no means invariable [2]

The term heat stroke is synonymous with exertional hyperpyrexia but is not the same as heat exhaustion although both are part of the spectrum of heat illness Table 1 compares the features of the two conditions

The principal difference between the two conditions is the rectal temperature if this is above 40°C then immediate action to lower the core temperature is required Oakley has recently reviewed the management of heat exhaustion[9] which will not be discussed further It should be noted that heat exhaustion is far more common than heat stroke

In the Services heat stroke most commonly occurs amongst soldiers performing arduous military training [10] but it has also been recorded during NBC training, diving training[11] and recreational marathon running [12]

Bizarre behaviour is often the first sign[13] and anybody who exhibits unusual behaviour or who collapses during arduous exercise should have their rectal temperature measured whatever the ambient temperature Most clinical thermometers only read up to 42 C but a core temperature of 46 5°C was recorded 2½ minutes after cooling started in a patient who survived [14] This supports the concept of the critical thermal maximum which postulates that it is the combination of duration and degree of hyperthermia that determines outcome [7] although there must be a temperature above which proteins are denatured regardless of the duration

TREATMENT

The aims of treatment are to cool the body rapidly maintain the circulation and to treat complications In the military environment casualties are often multiple [15] Treatment must start in the field and continue until the temperature is below 39°C because the longer the delay before treatment the poorer the chances of

Surgeon Lieutenant Commander Travis is now on the Emergency List having completed a SCC

Table 1 Comparison of Heat Stroke and Heat Exhaustion

	Heat Stroke	*Heat Exhaustion*
Usual circumstances	Arduous exercise in a hot environment	Same
Main problem	High core temperature	Salt and water depletion
Symptoms	Disorientation Delirium Coma Vomiting	Fatigue Cramps (Stokers Miners) Collapse (Heat syncope) Vomiting
Signs	Hot dry skin (not reversible) Hypotension	Cold clammy skin Postural hypotension
Rectal temperature	>40°C Usually 42°C	<40°C may be <37°C

survival Treatment can be summed up in three words

1 Strip
2 Soak
3 Fan

In the Field

The heat casualty must be moved to the shade All clothing should be removed and the casualty soaked with water The rectal temperature should be measured (a medical assistant usually provides cover for arduous military training) and if it is above 40°C the casualty must be evacuated immediately to the nearest medical centre Evaporative heat loss is enhanced by fanning This can be simulated by evacuating the casualty in an open vehicle [16] unless more exotic equipment is available [17 18] Ice packs in the axillae and groin have been advised [18] but this should be viewed with the same suspicion as the use of hot water bottles to re-warm hypothermia victims

In the Medical Centre

The rectal temperature must be checked on admission and the cooling process continued The traditional method of cooling has been to place the casualty in an iced water bath massaging the limbs to prevent vasoconstriction.[5] This is no longer popular because it causes intensive vasoconstriction,[19] increased metabolic heat production through shivering and difficulty in monitoring the rectal temperature Furthermore the loss of sphincter control usually makes the operation extremely messy

Cooling Evaporative cooling is the method of choice [19] It is more effective than immersion because the evaporation of 1 gm of water dissipates seven times as much heat as melting 1 gm of ice Evaporation also facilitates the return of cooled blood to the central circulation unlike immersion which depends on heat conduction through vasoconstricted tissue to cool the body core An evaporative cooling unit has been developed in Kuwait for heat stroke victims on the Makkah pilgrimage [20] The combination of a cool water spray and warm air flow ensures optimum cutaneous blood flow and evaporative heat loss with a favourable core-peripheral temperature gradient A simpler unit has now been described[21] which can be adapted from local resources

For practical purposes the naked casualty should be placed in the coma position on a trolley Continuous skin wetting on an open string mattress is ideal since this exposes the maximum surface area to cooling If this is not possible the casualty should be covered with a sheet soaked in tap water (20°C) Two or three electric fans should be positioned at 1 m to direct room air over the casualty The rectal temperature must be recorded every 5 minutes The optimum cooling rate appears to be 0 3°C every 5 minutes [4] Shivering may occur even with evaporative cooling [19] although this is less common if the skin temperature is maintained between 30°–32°C [4] by adjusting the fan speed and water temperature Cooling should

be continued until the rectal temperature is 39°C when active cooling should be stopped to avoid rebound hypothermia. In a medical centre where heat casualties are a common problem a multi-channel thermistor recorder to provide a continuous readout of temperature is advisable.

Fluids. 1 000 mls of 0·9% saline should be infused rapidly on arrival at the medical centre but this should take second place to starting evaporative cooling. Room temperature is usually 10°–20°C below core temperature so fluids need not be refrigerated in the United Kingdom. The amount of salt and water depletion is variable in heat stroke and 1 000 mls of crystalloid may be sufficient to replace losses [16]. From personal experience, however, large volumes of crystalloid may be required (up to 8 L N saline in 24 hours) and the amount should be titrated against blood pressure, urine output and peripheral perfusion. There is a theoretical risk of precipitating pulmonary oedema by transfusion because the peripheral vascular resistance rises as the temperature falls. This is unlikely in a fit young man and subjects tend to be undertransfused. An accurate fluid balance chart is essential in all cases and measurement of central venous pressure and hourly urine output is necessary in severe cases.

Drugs. Unlike the inherited condition of malignant hyperpyrexia, drugs have not been shown to be of value in the treatment of heat stroke. Shivering may need to be controlled and chlorpromazine (25–75 mg) is helpful [16]. Dantrolene was ineffective in a canine model [22]. Although vasodilators have been suggested to increase cutaneous blood flow [6] the usual problem is that peripheral vascular resistance is too low rather than too high. Aspirin (as an antipyretic) must be avoided due to its adverse effect on platelet function.

In Hospital

Heat stroke casualties should be transferred to hospital if local resources are inadequate or if complications such as convulsions, bleeding, oliguria and persistent hypotension occur. It is vital that body cooling continues en route. An initial temperature above 42°C and cooling time to 39°C of more than 1 hour are associated with a poor prognosis [23]. Other methods of cooling [13] such as peritoneal dialysis with cold fluids, artificial ventilation with cold air and ice cold gastric lavage are not widely used and are no substitute for evaporative cooling.

COMPLICATIONS

Hypotension

Hypotension in heat stroke is usually caused by a low peripheral vascular resistance [4]. It may also be caused by hypovolaemia due to dehydration, direct myocardial depression from temperatures above 41°C, metabolic acidosis or myocardial infarction [13]. Treatment is directed at cooling the patient to increase the vascular resistance and maintaining the circulation with intravenous fluids as discussed above.

Convulsions

Convulsions occur in about 10% of cases [6,13]. Convulsions increase metabolic heat production and should be treated promptly by a benzodiazepine in the first instance. A combination of chlorpromazine and pethidine has been advocated [24]. The coma position during treatment will help protect the airway and reduce the risk of aspiration.

Bleeding

Derangements of clotting indices are more common than clinical evidence of bleeding, although spontaneous bruising, oropharyngeal bleeding, epistaxis and haematuria may occur [25]. The cause is multifactorial with thrombocytopenia and hepatocellular damage being implicated with or without disseminated intravascular coagulation. Fresh frozen plasma is appropriate to control bleeding, but not to correct clotting indices alone.

Metabolic Acidosis

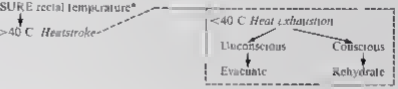
Acidosis secondary to hypotension, hypovolaemia and hypoxia occurs in about 50% [4]. Treatment should be aimed at restoring the circulation rather than correcting the pH with sodium bicarbonate. Arterial gas analysis should be corrected for body temperature. It is an unusual feature of heat stroke that hypokalaemia often occurs with the metabolic acidosis [4]. As long as the urine output is adequate, potassium may need to be added to the infusion fluids.

Renal Failure

Renal failure appears to be more common in exertional as opposed to non-exertional heat stroke [16], possibly because of rhabdomyolysis. The aim must be to prevent renal failure by prompt cooling and by maintaining the circulation in the early stages.

IMMEDIATE ACTION

1 MOVE to shade
2 MEASURE rectal temperature*



3 STRIP
4 SOAK
5 FAN
6 EVACUATE

MEDICAL CENTRE

1 COMA position on trolley
SOAK (spray or sheet)
3 FAN ? or 3 electric fans
4 IVI N/Saline 1 000 mls rapidly
5 MONITOR —Rectal temperature (every 5 minutes to 39°C)
Blood pressure (every 15 minutes)
Urine output (catheterise if unconscious)
Fluid balance
Skin temperature (30° 32°C if possible)
6 COOL to 39 C

HOSPITAL

1 TRANSFER AFTER INITIAL COOLING IF
Cooling time to 39°C>1 hour
Persistent hypotension
Convulsions
Bleeding
Oliguria
2 CONTINUE EVAPORATIVE COOLING
3 SUPPORT CIRCULATION
4 MEASURE —Full blood count (esp platelets, haematocrit)
Urea electrolytes
Clotting (INR, KCCT FDPs)
Liver function tests
Arterial gases (correct pH for temperature)
ECG

*If thermometer not available treat as heat stroke

Fig 1 Summary of Management

Death

Mortality is between 10% and 30%.[8,11] Whilst the mortality from heat stroke has been dramatically reduced by early and effective treatment it is a rare year that at least one British serviceman does not die from heat stroke.[7,8]

PREVENTION

The principal predisposing factors[12] to heat stroke are

1 Hot humid environment
2 Dehydration
3 Lack of acclimatisation
4 Poor physical fitness
5 Inappropriate clothing
6 Pre existing febrile illness
7 Inadequate Command appreciation of the risk

Arduous exercise in the summer should be performed in the early morning or in the evening. The British Army uses the Wet-Bulb Globe Temperature (WBGT) Index as a guide to the risk of heat illness but casualties may still occur when the Index is low.[10]

Water should be freely available and compulsory water stops planned if more than 45 minutes exercise is performed.[27] The hazards of heavy alcohol consumption on the night prior to arduous exercise should be explicitly explained.[28] It is the responsibility of the Unit Medical Officer to educate the training executive. Instructions about preventative measures should be incorporated into Training Standing Orders.

CONCLUSION

Heat stroke is recognised by the history and the combination of disturbed consciousness with a rectal temperature above 40°C. Evaporative cooling should start immediately using a strip-soak-fan regime. Complications can be reduced by early cooling and maintaining the circulation with intravenous fluids. Prevention is both feasible and effective. The diagram (*Fig 1*) summarises the management.

ACKNOWLEDGEMENTS

I would like to thank Surgeon Captain F St C Golden OBE RN for his advice and Mrs M Evans for typing assistance.

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J roy nav mad Serv 1988 74 44–50

An Audiological Survey of Aircrew

D G Jones

Abstract

A cross sectional survey of Royal Naval aircrew was performed to measure the prevalence of noise induced hearing loss and assess its relationship to flying experience. The quality of routine audiometry undertaken at annual aircrew medical examinations was assessed and the requirement for further hearing conservation measures amongst Fleet Air Arm personnel considered.

Analysis of the results indicated that 3.8% of aircrew had possible noise induced hearing loss. In 1.6% this was probably due to flying and none of these cases had less than 2 000 hours flying experience.

Further surveys should concentrate on experienced aviators and on aircraft maintainers and handlers.

As noise induced hearing loss does not appear to be affecting aircrew with less than 10 years flying experience there is a potential saving in time and expense by ceasing to do routine audiometry on this group.

INTRODUCTION

It has been known for many years that exposure to excessive noise can cause damage to hearing. In some cases a degree of recovery from this noise induced hearing loss may occur although whether this happens or whether the hearing loss is permanent depends on a number of factors, principally the intensity of the noise and the duration of exposure.

The earliest reference to noise and deafness generally seems to be attributed to Ramazzini[1] in 1713 who noted that coppersmiths hammering copper have their ears so injured by this perpetual din ... that workers of this class become hard of hearing and if they grow old ot thus work perpetually deaf'. Millers were apparently affected in the same way by the constant noise of wheels and millstones and the roar of water falling from a height. It is perhaps worth noting in passing that some authorities would claim that Ramazzini's account was predated by many centuries by a reference in the Apocrypha of the Old Testament (Ecclesiasticus 38.28) concerning the blacksmith "the noise of the hammer and the anvil is ever in his ears" apparently an allusion to the tinnitus which may accompany noise-induced hearing loss[1].

Fosbroke[2] in an article in the *Lancet* in 1831 writing about deafness described noise as a possible cause specifically in blacksmiths. The first recorded use of hearing protection was by Barr[3] in 1885 who noted boilermakers caulkers and riveters working in shipyards are extremely liable to dullness of hearing this apparently affecting over 75% of those he observed. On experiencing the noise these workers were exposed to at first hand he wrote I fortunately furnished myself with a couple of India rubber plugs and by carefully inserting them in the canals of my ears I was able at pleasure to shut out the fearful sound. Let no one who values his hearing perform such an experiment without similar precautions. Useful advice which unfortunately was not followed for many years.

In 1934 the Chief Inspector of Factories and Workshops in his Annual Report[4] commented Only in comparatively few cases do the workers appear conscious of any inconvenience sufficient to justify the wearing of ear protection. There seems to have been a general acceptance of the inevitability of hearing damage in noisy occupations as witnessed by the lack of supply or usage of hearing protection

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and the apparent inability to reduce industrial noise at source However from about 1940 onwards more attention was directed to occupational health in general and improvements in techniques for measuring noise levels and hearing loss enabled a wide range of industrial situations to be studied for occupational hearing damage

An example of one of these studies was one of the earliest investigations carried out on hearing loss in aviators by Dickson Ewing and Littler (1939) [5] They showed that permanent hearing loss of the same nature as other types of noise-induced hearing loss appeared after exposure to the noise of piston engined propeller driven aircraft although the extent varied between individuals and the risk was diminished by protecting the ears Dickson and Watson[6] followed this by studying the effects of jet engines on service personnel, coming to similar conclusions regarding the hearing loss and in addition noting tinnitus and vertigo in very severe noise exposure Dickson went on to suggest in 1953 [7] that 90 decibels should be the danger level for continuous noise some years before it was finally adopted (in this country) In the same year the first question on the subject was asked in the House of Commons concerning whether the Government was taking steps to protect the hearing of men employed in the operations of chipping riveting and other such noisy procedures [8]

At this time the control of industrial noise and protection of the workers was still very much a task for individual companies how ever a succession of Government publications[9 10] culminated in 1972 with the Department of Employment s Code of Practice for Reducing the Exposure of Employed Persons to Noise [12] This publication although not having the actual status of law was the definitive document on the reduction of exposure to noise and protection of hearing in industry until 1981 when the Health and Safety Commission published proposed Regulations and a draft Approved Code of Practice and Guidance Notes for Protection of Hearing at Work

The effects of noise on hearing in service personnel have long been realised particularly in two fields personnel exposed to gunfire and explosions and those exposed to noisy engines eg in a ship's engine room or near aircraft Prior to 1945 this had been accepted as an inevitable hazard of service life however in line with the general increased awareness of the preventable nature of noise-induced hearing loss sporadic attempts were made in the 1950 s to reduce noise exposure in specific situations, eg by making ear plugs and muffs available to personnel who were exposed to excessive noise The first formal instruction to the Royal Navy was an Admiralty Fleet Order issued in 1954 [13] which gave instructions on hearing protection Subsequently hearing conservation programmes have evolved in all three services current procedure for the Royal Navy being found in a Defence Council Instruction issued in 1979 [14] Thus there now exists a considerable body of legislation regarding hearing conservation and the medical literature attests to the effectiveness of hearing conservation programmes

Gosztonyi[15] assessed the efficiency of hearing protection measures by performing audiometry five years after the institution of these measures and found no significant difference between workers in low noise areas and those in high noise areas who had worn ear muffs A previous study by Pell[16] had obtained broadly similar results, and although there were some slight statistically significant differences between the groups it was concluded that these were due primarily to the large sample size and that the magnitude of the differences was too small to be biologically important These two studies also pointed out a number of factors which could confuse the evaluation of a hearing conservation programme such as pre-existing disease non occupational noise exposure and the degree of compliance of the workforce in the use of hearing protection It is worth noting that Else[17] has shown that ear protection must be worn for a very high proportion of the time to be effective and removing uncomfortable muffs or plugs for a short period of time to ease the discomfort may result in considerable hearing damage Fortunately for aircrew this would not appear to be a problem as it is not customary to remove the flying helmet whilst flying!

The development of the flying helmet which made of canvas or leather had originally been primarily for protection against cold and the weather proceeded with the incorporation of ear muffs initially it must be said purely to aid radio communications however the advent of the hard helmet with a padded interior which itself gives quite good protection to the hearing, signalled the first positive attempt to avoid noise induced hearing damage in aircrew Since then research has been carried out at the Institute of Aviation Medicine and the Royal

Aircraft Establishment at Farnborough Hampshire in order to assess more accurately the noise hazard to aircrew and to improve the hearing protection offered by flying helmets and reference will be made later to some of the publications resulting from this work.

Despite these efforts problems may still occur. Lieber[18] an American Air Force doctor at an American air station in Britain noted that 86% of the flying personnel on one particular squadron had apparent hearing loss and although in some cases this was temporary and therefore reversible on removal from the squadron there was a far higher proportion of aircrew with permanent hearing damage than had been experienced previously. After investigation this was ascribed to a combination of insufficient noise attenuation by the flying helmet in what was a very noisy aircraft—supersonic F100 jets which often took off in pairs—and in addition exposure to excessive noise whilst in the squadron building, which was situated too close to the runway. The conclusion of this and most other authors is that a properly organised hearing conservation programme should effect a significant reduction in the damage to the hearing of workers exposed to excessive noise.

The Royal Air Force and the Royal Navy have performed regular audiometric tests on aircrew since the mid-1970s[19,20] and these together with otological examinations done at the annual medical to assess fitness to continue flying allow a continuous appreciation to be made of hearing status. For Royal Naval aircrew this has to remain within the standards laid down in a Defence Council Instruction issued in 1980 (DCI RN 356/80) otherwise referral to an otological specialist is required. Anecdotal evidence suggests this is rare and removal of aircrew from flying is even more uncommon. A noise survey by Coles and Richardson[21] in 1970 suggested that noise levels in Royal Navy helicopters taken in conjunction with the duration of exposure which might be expected in an average flying career were sufficient to cause some cases of hearing loss amongst aircrew and this was confirmed in subsequent work by Reed and Glen[22] in 1977 and Uren Reed and Morse[23] in 1975.

This survey therefore was an attempt to assess the prevalence of noise-induced hearing loss amongst Royal Naval aircrew. It was also hoped to relate this if possible to the number of hours of flying experience thus being a good indication of the duration of noise exposure. Additional aims were to assess the quality of routine audiometry undertaken at the occasion of annual aircrew medical examinations, and to review the use of audiometric screening, in particular in the context of the Royal Navy's hearing conservation programme.

METHOD

There are many problems in designing a satisfactory audiometric survey ie one in which the presence or absence of noise-induced hearing loss may be demonstrated and if present related to industrial noise exposure. Some of the general difficulties will be discussed later but it is proposed to cover here specific problems which arise in a survey of Royal Naval aircrew.

The Royal Navy has several hundred active flying personnel in addition to which there are a number of personnel who have ceased to fly and are now employed in non flying jobs such as general administration or in sea going executive billets. Whilst it would be technically feasible to trace these ex aviators within the Navy it would present a difficult task to organise access to a sufficient number to make a survey worthwhile. There are also ex aviators who have completed their service in the Navy and are now civilians and virtually untraceable. In any case this survey is intended primarily to screen a sample of the current active flying population although even this is no easy task. The personnel concerned are dispersed throughout the three main Naval Air Stations two smaller Air Stations, a considerable number of ships on overseas detachments on training courses in temporary non-flying jobs and on exchange to other Services. This wide dispersal makes it not only impossible to perform an accurate comparable audiometric survey on all aircrew but also difficult to achieve instead a truly random representative sample.

One factor all aircrew have in common is the need for an annual flying medical examination at which an audiogram is performed the majority of these being done at the three main Air Stations. There should be no systematic bias either in where aviators have their medicals performed or in the time of year that it falls due for any particular individual. Therefore a fairly simple questionnaire was designed to be completed at each aircrew medical examination undertaken at the three main Air Stations during a three month period. The details required from the aircrew included date of birth aircrew type length of RN service

years flying flying hours by type of aircraft and date of last flight (to rule out temporary threshold shift) The medical officer was required to record the details of the otological examination and establish if possible any alternative causes for any hearing loss present such as exposure to gunfire noisy hobbies medical conditions or drugs

Audiograms were performed using the same type of self-recording audiometer at each Air Station a Grason Stadler 1703B Self-Recording Audiometer presenting pulsed (200 msec duration) pure tones in the left then the right ear at the following frequencies 0 5 1 2 3 4 6 and 8 kHz with a 1 kHz test frequency at the start of the test Audiometric tests were done inside audiometric booths designed to keep ambient noise levels down to the extremely low levels required to permit accurate measurement of the hearing threshold [24] In addition to the instruction manual supplied with the audiometer the Institute of Naval Medicine issues guidance notes on audiometry [25] in an attempt to ensure standardisation of operating technique The audiometers are calibrated at the Institute of Aviation Medicine and every week during the survey period at each Air Station a nominated individual with normal hearing, had an audiogram as a test to demonstrate that the calibration had not varied. The resulting record was initially scrutinised by the examining medical officer as, in some cases of abnormality a repeat audiogram might have been required followed by referral to an otological specialist Following this a copy of the audiogram was attached to the questionnaire ready for collection and subsequent analysis Preliminary enquiries had revealed that approximately 200 sets of data would be available for analysis by the author Baseline audiograms were also available for comparison to exclude pre exposure abnormalities

RESULTS

At the end of the survey period 184 completed questionnaires and audiograms were available for analysis Table 1 details the numbers of normal/abnormal audiograms within the aircrew groups Table 2 shows the audiogram results related to flying hours The criteria used in assessing audiograms are listed below From the information on the questionnaire and the type of audiogram abnormality the probable cause for the abnormality could be deduced ranging from non flying noise exposure to pre existing hearing loss from past medical problems Excluding these left three probable cases of noise induced hearing loss related to flying

Criteria Used in Assessing Audiograms

1 *Validity of Audiogram*

(i) There should be at least six reversals of the trace

(ii) The peaks should not deviate by more than 10 dB among themselves

(iii) The valleys should not deviate by more than 10 dB among themselves

(iv) Providing the trace excursions are regular the hearing level may be obtained by eye-averaging ie taking the middle of trace

2 *Presence of Abnormality*

The first question to be considered is the variation of normal subjects ie the normal range Secondly allowance must be made for the effect of age on hearing (presbyacusis)

The author has taken guidance mainly from Burns[28] in Noise and Man and using the values for standard deviation given on page 98 the following were used as limits of the normal range

Table 1 Numbers of Normal/Abnormal Audiograms within Aircrew Groups

Aircrew type	*Normal*	*Abnormal (No.)*	*Abnormal (%)*	*Total*
Pilots	79	4	5	83
Observers	48 162	3 11	6 6.4	51 173
Aircrewman	35	4	10	39
Maintainers	7	2	22	9
Photographers	2	—	—	2
TOTAL	171	13	7	184

Table 2 Audiogram Results related to Flying Hours

Flying hours	*No*	*Abnormal*	*%*	*No PNIL due to flying*	*%*
0 499	53	4	7 5	—	—
500 999	37	—	—	—	—
1 000–1 499	25	1	4	—	—
1 500 1.999	28	—	—	—	—
2 000–2 499	14	1	7	1	7
2 500–2 999	8	—	—	—	—
3 000–3.499	8	1	12 5	—	—
3 500–3 999	7	3	43	1	14
4 000–4 499	4	3	75	1	25
TOTAL	184	13	7	3	1 6

kHz	*SD ×2*
0 5	13 0
1	11 4
2	12 2
3	13 0
4	13 8
6	16 2

Age corrections were taken from page 102 as follows

Frequency	0 5	1	2	3	4	6	kHz
Age							
30	0 5	1	1 5	2	3	4	Age
40	2 5	3	1 5	5	6	10	Correction
50	4	5	6	10	17	16	in dB
Years							

3 *Type of Abnormality*

There are many different causes for hearing loss some of which produce characteristic audiograms The usual indication of noise induced hearing loss on an audiogram is taken to be a dip centred around 4 kHz This however is merely a sign of cochlear damage, and other causes for this must be excluded These include ototoxic drugs such as quinine and streptomycin some industrial poisons such as benzene and carbon disulphide and certain diseases and infections[24] It is also usually accepted that occupational hearing loss is bilateral and fairly symmetrical Asymmetric hearing loss is usually due to firearms or disease

DISCUSSION

From Tables 1 and 2 it can be seen that in this sample of 184 13 audiograms (7%) were classified as outside the normal range and of these 3 (1 6%) had possible noise induced hearing loss related to flying Of the other abnormal audiograms 4 (2 2%) had possible noise-induced loss Two of these were probably secondary to small arms firing and the other two were experienced aircraft maintainers who would have been exposed to considerable amounts of noise on the ground, this being a far more likely cause than their minimal flying experience Since these latter two with 13 and 18 years of Naval service were among only 9 maintainers in total present in the sample (with lengths of service ranging over an even spread from 4 to 32 years) this does perhaps indicate the need for further investigation of hearing levels in aircraft maintainers, who usually rely on wearing ear muffs for hearing protection

The three cases of possible flying induced hearing loss had 2 092 3 970 and 4 480 hours of flying time respectively this variation possibly being explainable in terms of the difference in individual susceptibility or alternatively by some additional noise exposure undiscovered by the survey The prevalence of noise induced loss must in any case be compared with the distribution of flying hour totals within the sample which shows an approximate exponential decline and therefore a corresponding decline in the numbers at risk in the higher categories The research from the Royal Aircraft Establishment[22 23] suggested risks of hearing handicap varying between 4% and 19% for different aircraft assuming retirement from flying at age 55 years Since only small numbers of aircrew remain active in flying until this age, even a 19% risk would produce a very small

number with hearing handicap Extending this approach to this survey would explain the extremely low prevalence (1 6%) of possible noise-indnced hearing loss although it is still instructive to note that two of these cases form 18% of the 11 members in the sample with over 3 500 hours flying experience This percentage must be interpreted with caution bearing in mind the small number involved

The overall quality of audiograms was satisfactory although it could be argued that this was to be expected when they were being produced for a survey It appears that the frequency of audiometry for particularly the relatively inexperienced aircrew (under 5 years flying) is somewhat excessive given the number of normal audiograms in this survey Indeed it is debatable whether given the improvement in noise attenuation by the Mark IV flying helmet [26] any audiograms should be required in future before aircrew have achieved 9 or 10 years flying experience In some aircrew this would mean a pre-entry audiogram followed by an audiogram at release medical The former is essential in order to establish a baseline prior to flying and to screen out candidates with defective hearing The latter is necessary in order to prevent subsequent claims of hearing loss in the Service which have actually been sustained after leaving

It is important that audiometers are calibrated and maintained correctly for the practice of audiometry to have any use Woodford[27] has shown that two audiometers can differ by as much as 10 dB(A) yet still be within calibration tolerance limits and since some surveys have shown between 30% and 90% of the audiometers examined to be outside these limits the huge possibilities for error become apparent The author knows of one case where an audiometer was producing faulty results due to poor connections between the ear pieces and the audiometer

CONCLUSIONS

Noise-induced hearing loss is not affecting aircrew who have less than 10 years flying experience given the current number of hours flown per year It would save some time and expense to cease performing routine audiograms on this group of aircrew although at the possible risk of missing the occasional non-flying related hearing problem.

Audiometry remains a useful clinical tool for screening more experienced aircrew and otherwise when clinically indicated It is essential that audiometers are regularly maintained and calibrated

Further hearing surveys on aircraft handlers and maintainers are required

ACKNOWLEDGEMENTS

The author wishes to particularly acknowledge gratefully the advice and assistance given by Surgeon Captain D S Wright Royal Navy during the planning and execution of this project

In addition thanks are due to the following for their assistance

Air Commodore M J Pallister Royal Air Force

Surgeon Captain J M Young, Royal Navy

Doctor Graham Rood Royal Aircraft Establishment

The Principal Medical Officers, medical staff and assistants and nursing staff of the three Air Stations involved without whom this survey could not have been completed

The aircrew who gave their full co-operation and took part in the survey

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J roy nav med Serv 1988 74 51–54

Hyperbaric Oxygen in Osteoradionecrosis of the Mandible

R. E. O. Daum and T. W. Negus

Summary

A case of recurrent osteoradionecrosis of the mandible presenting 15 years after radiation therapy is treated by a combination of surgery, antibiotics and exposure to hyperbaric oxygen. Mucosal cover of bone that had been exposed for six years was obtained after 18 days treatment. Osteoradionecrosis and the rationale behind its treatment with hyperbaric oxygen is discussed.

INTRODUCTION

Osteoradionecrosis is a pathological process that can follow heavy irradiation of bone and may cause chronic pain, necrosis and injection accompanied by late sequestration and sometimes permanent deformity.

First noted in 1922 case reports became more frequent in the 1950s a large number involving the mandible, as radiation of intra-oral malignancies became more common. Currently the mean incidence of osteoradionecrosis in patients radiated for therapy of cancer in the oral cavity and oro/nasopharynx is 10–15%.[1]

A wide range of presentations is possible from a small area of ulceration that heals spontaneously through to a progressive symptomatic disease. Complications of the latter include pathological fracture, fistula formation and local or systemic infection. It has been estimated that the risk of mortality from these sequelae is 10–20% despite cure of the original cancer.[2]

In the mandible, which is more prone to radiation damage than the maxilla, mucosal ulceration exposing necrotic bone is frequently found and may be accompanied by paraesthesia or anaesthesia due to involvement of the inferior alveolar nerve. Food trapping and irritation of adjoining structures by roughened bone may also be a problem. The increased susceptibility of the mandible to osteoradionecrosis is thought to be due to a number of factors.[3] These include a relatively poor blood supply and a compact bone structure that scatters radiation.

The pathological process of osteoradionecrosis starts with radiation damage to cells of all types. This causes endothelial destruction, thrombosis of vessels, increased fibrosis of the mucosa, connective tissue and periosteum and necrosis of osteoblasts and osteocytes. The end product is an organ that is hypovascular, hypocellular and ultimately hypoxic[4] which may then become infected due to its reduced resistance. The higher the total radiation dose as associated with implant or supervoltage sources the greater the damage to cells and the lower their ability to repair. Osteoradionecrosis occurs spontaneously when cellular replacement falls below the normal rate of cellular turnover and is therefore more likely after trauma, operative or other, as this increases the demand for tissue repair.

The damage caused to blood vessels and therefore the tissue oxygen supply at a local level provides a rationale for the use of hyperbaric oxygen in osteoradionecrosis.

CASE REPORT

In 1972 a 59 year old man had undergone a full

Squadron Leader Daum is a Consultant Anaesthetist, Wing Commander Negus is a Consultant in Oral Surgery. Both officers are serving at the Princess Mary's RAF Hospital, Akrotiri (Cyprus).

course of radiation therapy for a well differentiated invasive squamous cell carcinoma in the left retro-molar region

A full dental clearance was carried out prior to the treatment which cleared the carcinoma but left him with a patch of osteoradionecrosis and exposed bone in the left maxilla. This responded to conservative measures: oral hygiene and long term antibiotics.

In 1984 the patient noticed some swelling of his left cheek with no pain or change in sensation. The body of his left mandible was enlarged and he volunteered the information that he had had to have his denture eased recently in this area. X rays showed a patchy radiolucency in the (46) (47) (48) region with some loss of cortex of the upper surface of the mandible. This area was curetted, the mucosa closed and histology confirmed osteoradionecrosis. However the wound broke down in the post operative period and long term antibiotic therapy was recommenced. This resulted in partial healing and he remained symptom free albeit with a small portion of exposed bone in the (48) region and radiological appearance as shown in *Fig 1* until early 1987.

Fig 1 Radiograph showing appearance of the defect in left mandible taken in 1985

At this time the patient complained of pain and swelling in the mandible. There were no neurological symptoms but radiography showed a more moth eaten appearance of the bone than before as see in *Fig 2*. He was placed on long-term doxycycline therapy and oral hygiene maintained. At review one month later his symptoms had not resolved and he was admitted for biopsy and curettage of the region.

Fig 2 Radiograph of left mandible on this presentation showing increased areas of lucency

The (46) (47) (48) region was exposed via an intra oral incision the bony cavity thoroughly curetted and primary closure obtained without tension. There was no histological evidence of tumour recurrence but bacteroides was cultured from swabs taken at operation. Post operatively doxycycline therapy was continued and metronidazole added. However after 10 days the wound had broken down revealing an area of bone 5 cm × 1 cm as shown in *Fig 3*. It was decided to treat this with hyperbaric oxygen in an attempt to encourage wound healing.

Tetracycline therapy was continued and the patient was urged to give up smoking which is a powerful oral irritant and inhibitor of healing. The chamber used was a Clucas 6 man twin compartment model and has close fitting masks for breathing 100% oxygen with overboard dump of expired gas. In view of the patient's age (74 years) coincidental deafness and some evidence of ischaemic heart disease he was accompanied in the chamber by a medical attendant.

Dives were to 15 m of sea-water pressure and 100% oxygen was breathed for a total of 90 minutes. To protect against harmful effects of oxygen on the lungs 10 minute air breaks were employed at 30 and 60 minutes and vitamin E 400 iu was given daily.[5] Decompression was slow at 0·6 m/min with a 15 min stop at 3 m. Total chamber time was 2 hrs 30 mins. This was carried out for 12 days and then alternate days for a further week making a total of 15 treatments. After the ninth treatment granulation tissue was noted over the bone

Fig. 3 Intra oral appearance. A defect in mucosal cover. Bare bone and mucosal edges are clearly visible

extending in from the edges of the wound and by the end of treatment complete mucosal cover had been obtained.

There were no problems during chamber therapy apart from an otitis externa which grew pseudomonas and was treated with gentamicin drops.

Review at 6 months showed sound mucosa covering the site of the previous defect and appearance as shown in *Fig 4*.

Fig. 4 Appearance of mucosa 6 months after hyperbaric therapy

DISCUSSION

The risk of developing osteoradionecrosis is greatest in the first 12 months after radiation but continues for years due to the permanent reduction in healing capacity[1] and may be precipitated by denture irritation, dental extractions or further jaw surgery.

Treatment of osteoradionecrosis is based for the minor and non-progressive lesions on conservative measures such as long term antibiotics and mouth hygiene together with avoidance of irritants such as poorly fitting dentures, alcohol and tobacco. Most studies now agree that large, symptomatic or progressive lesions are best treated by a combination of wound debridement, antibiotics and hyperbaric oxygen for which many protocols have been published. However the low availability of chambers will limit this ideal approach[1,6,7].

It has been shown that wound healing progresses via proliferation of fibroblasts and synthesis of collagen which provides a basis for capillary budding and areading into the previously avascular areas[8]. Oxygen tension rises as area blood flow increases and further proliferation of fibroblasts is encouraged. Ischaemic and hypoxic wounds such as those caused by osteoradionecrosis fail to reach the tissue oxygen tensions needed to stimulate these normal healing processes.

Hyperbaric oxygen can be used to intermittently raise the tissue oxygen tension above the critical, thus promoting healing[9] and has been shown to enhance epithelialisation and improve wound closure rates[10]. In addition the bactericidal activity of leucocytes in hypoxic wounds is improved if the tissue oxygen tension can be raised to 30 mm Hg[1].

The aim of hyperbaric oxygen and other measures in this case was not to revitalise dead bone an unrealistic prospect in the relatively short treatment time scale but to improve healing of the mucosa and provide a "water tight" seal as a barrier against further infection. Revascularisation and improvement in the condition of the underlying bone may then occur in time.

Exposed bone that had been present for some 6 years with no signs of obtaining mucosal cover was fully covered after 18 days treatment.

The indications for hyperbaric therapy that

have a sound physiological basis and are backed by controlled experiment are limited to decompression sickness gas embolism carbon monoxide poisoning, gas gangrene, refractory osteomyelitis osteoradionecrosis soft tissue radionecrosis and the improvement of wound healing in other ischaemic hypoxic wounds [12]

This case would seem to confirm the efficacy of hyperbaric oxygen in a combined approach for the treatment of osteoradionecrosis

ACKNOWLEDGEMENTS

The authors would like to thank the operators of The Princess Mary's Hospital compression chamber for their help with this case Mrs Sue Richards for her secretarial help and the Director General Medical Services (RAF) for permission to publish

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The Royal Naval Medical Club Dinner 1987

The Southern Royal Naval Medical Club Dinner 1987 was held in the Wardroom HMS *Nelson* on Friday 9 October 1987 **Surgeon Rear Admiral G J Milton Thompson QHP FRCP** Medical Director General (Naval) presiding The Commandant General Royal Marines **Lieutenant General J M C Garrod OBE** was the principal guest

The Medical Director General (Naval) made the following speech

Commandant General distinguished guests ladies and gentlemen I am particularly grateful to the Commander of *Nelson* for allowing us to dine here tonight Many of us joined the Navy here and it is a great pleasure to be back.

I am delighted to welcome as our principal guest, **Lieutenant General Martin Garrod** the Commandant General of the Royal Marines The Royal Naval Medical Service has a very close association with the Corps and the greater part of the naval support to the Royal Marines is medical Many of these appointments require commando training but we have many volunteers who after a demanding training, are very proud of their green berets Our people who have once served with the Corps are always very ready to go back We have another thing in common with the Royal Marines both we and they are always regarded as soft targets when the financiers in the Ministry of Defence are looking for yet more cuts Soft targets we may be in the eyes of some we both have hard centres

Among our guests tonight I am very glad to welcome Professor **Philip Rhodes** who has just retired as Postgraduate Dean at Southampton He has been a good friend to us in all matters concerning the postgraduate education of our people in Wessex and I would like to record our warmest thanks and our best wishes for his retirement **Dr Mckee** of the Wessex Regional Health Authority is also well known to those who have worked or now work in Wessex and is very welcome Those of you who now enjoy the luxuries of the cross link at Haslar have much to thank Rear Admiral **Charles Weston** for When he was Director of Quartering it was he who persuaded the Admiralty Board to proceed with the long overdue modernisation of Haslar and the building of the cross-link

Sadly two senior officers and good friends from the Royal Air Force are dining with us for the last time in uniform. **Air Vice Marshal Freddie Horrell** Director General of Medical Services, Royal Air Force retires at the end of the year and will be sadly missed **Air Vice Marshal John Jones** completes his tour as the first Director of Defence Dentistry at the end of the year in post he has filled with distinction and we shall be sorry to see him go

We are very grateful to **Commander Alan Johnson** Wardroom Mess President and Commander of *Nelson* for allowing us to dine here tonight and I am very glad that he can be with us We are also most grateful to **Barry Sewell** the Mess Manager and his staff for giving us such a splendid evening

As most of you will recall it is customary for the Medical Director General to give some indication of how things are with the Royal Navy and its medical service I have done my best to get round more divisions of the Royal Naval Reserve this year and have recently been to Haslar some of you will therefore have heard something of what I have to say already

Manpower remains extremely tight and manpower ceilings remain the major financial regulator As you will recall from a year ago our problems have been exacerbated by the severe

shortage of Medical Assistants which has reached its trough about now and which I expect to improve next year with the hope that we will be back to full strength in about eighteen months To help with this the new QARNNS Medical Assistant is now being recruited and the first are going through part one training at Raleigh

We are still having to consider the down stream effects of Sir Henry Yellowlees attempts to produce a satisfactory reorganisation of the Defence Medical Services Studies are now going on in the area of the medical component of the command structure It is evident that there are those in the centre who still wish to see a purple medical service as a tidy budgetary unit although this is contrary to stated Government policy and would bring chaos to our support for the teeth arms The Surgeon General **Sir Cameron Maffat** sadly umble to be with us tonight has put this dilemma very neatly If he has pointed out Commands are to be served by a purple medical service then they must expect it to operate as an agency the closest analogy to which is the Property Services Agency Certainly as Surgeon General (Designate) I have no intention of presiding over the dissolution of the Royal Naval Medical Service nor of the medical services of the Army and Royal Air Force

The constant battles in the Ministry of Defence underline the need for our best people to get staff training and Ministry experience at an early stage in their career This is often seen in the short term as interfering with professional training this need not interfere with a clinical career but will rather complement it

It is good to see the Queen Alexandra s Royal Naval Nursing Service both regular and reserves well represented here tonight We have a greater need of them than ever and as I have already mentioned the first QARNNS Medical Assistants will have completed training this time next year That late twentieth-century folly Project Two Thousand is already embarrassing us severely since there is an acute shortage of that particularly important nurse the Enrolled Nurse (General) It is clear that we cannot wait to follow the National Health Service in trying to make some practical sense out of this absurd scheme but must make our own plans with all speed To this end the Matron in Chief has just completed a report with particular reference to the patient care assistant so that we may bring some order out of the present chaos

It has been suggested that to ease our present difficulties with nurse shortages we should abandon training Registered General Nurses This would give us a short term advantage at the expense of long term disaster and I am totally opposed to any such move

The Royal Naval Reserve goes from strength to strength The PMOs heard today that real progress is being made The medical RNR is expanding to fulfill a defined war role and a new type of reserve rating—the Medical Support Assistant (MSA)—is coming into being to take an important place in the medical ORBAT I am very grateful for all the support the regular medical service receives from our colleagues in the reserves

It is incumbent on the Medical Director General to be optimistic and in this I have no difficulty However with the additional responsibilities that are to be thrust upon me next year I am not discharged from those of MDG(N) and it will be less easy for me to maintain that personal involvement in all respects of the Royal Naval Medical Service that I believe to be so important But there is much to be done on the tri-service front building on the foundations that General Moffat has so surely laid and I believe that this work will be of benefit to you all Most importantly it will enable us better to fulfil our prime task—to support the Royal Navy and the Royal Marines in War

Members of the Royal Naval Medical Club I ask you to rise and drink to our guests

Lieutenant General Garrod replied on behalf of the guests and proposed the health of the Club

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BOOK REVIEWS

Cash's Textbook of Chest Heart and Vascular Disorders for Physiotherapists (4th Edition) Ed Patricia A Downie Pp 704 Fsbm and Faber London £10 95

This latest edition of a now familiar book to all therapists shows radical revision of both layout and content when compared to its now somewhat jaded predecessor This compindz text has undergone change and accurate updating to take account of modern advances in knowledge management and treatment techniques

The book's format remains with the tradition of this series where minimal chapters are complemented by sections which consider specifically physiotherapy It is thus that contain a significant change of approach from a recipe book summary of treatment, to one of identifying therapeutic objectives and emphasising a problem-solving approach This accurately mirrors today's clinical trends and indeed those of physiotherapy education

Completely new chapters cover such topics as applied physiology neonatal and paediatric intensive therapy major organ transplantation chronic respiratory failure and cardiac and respiratory pharmacology Noteworthy new inclusions also detail patients experiences of Coronary Artery By Pass surgery and Assisted Ventilation Elsewhere in the text there are numerous reminders of the importance of establishing good relationships with patients and their families with particular reference to their subsequent co-operation and compliance Finally on an associated theme the silent bibliography covers a number of relevant titles on the complex range of moral and ethical dilemmas in medicine that encourage to increasingly involve clinical therapists working in this area

One noticeable short coming of the book is the inconsistency in referencing between chapters and their authors In its role as a standard reference work this book will undoubtedly frustrate many readers who seek to follow-up specific areas or ideas However this book must remain the definitive text for use by qualified therapists of physiotherapy Its inclusion in the libraries of both schools and departments is therefore thoroughly recommended

AC

ABC of Hypertension (2nd Edition) Pp 52 British Medical Journal £4 95 inland £6 50 overseas

This second edition of the BMA publication compiled originally from articles appearing in the BMJ has been revised to incorporate the findings and recommendations of the current high/main hypertension and its Clear advice on equipment and measurement techniques is given before a discussion of indications for treatment and a review of both non pharmacological and drug therapy Both hypertension in pregnancy and hypertensive emergencies are adequately covered for the non specialist.

The illustrations are helpful in highlighting the clear text in which there are few typographical errors It is unfortunate that the stated maximum dose of prazosin exceeds that of the manufacturers as otherwise the data on drugs is well presented

Overall this ABC is an excellent booklet covering a difficult subject in a non-pedantic yet concise manner and is highly recommended to anyone involved in measuring blood pressure and managing hypertension

MLC

ABC of AIDS Ed M W Adler Pp 57 British Medical Journal £4 95 inland £12.50 overseas

In some centres in the United States newly qualified interns during their training have seen more cases of *pneumocystis carinii pneumonia* than pneumococcal pneumonia and more cases of Kaposi's sarcoma than breast cancer—such is the impact of AIDS This is not yet the situation in Britain but with estimates of at least 60 000 who are infected with HIV more and more clinicians in more and more district general hospitals (and service hospitals) will be encountering AIDS related illnesses.

This book does not purport to be an all embracing reference text on AIDS but it aims to inform doctors and other health care workers about the AIDS

problems which we all come to face soon and give us some practical advice on how to deal with them The book is a collection of essays by different authors most of whom are on the staff of the Middlesex Hospital which together with St Stephen's and St Mary's sees the majority of AIDS patients in this country As is usual in the British Medical Journal series of "ABC" reviews the articles are liberally annotated with diagrams and tables which help to give a very clear exposition The photographs in colour and black and white are of very high quality and are plentiful without becoming irrelevant

Each individual chapter is excellent and the series hangs together well with no glaring omissions nor tedious repetitions Two articles are written by patients who are infected with HIV (one of whom is well at the time of writing and the other of whom has AIDS) Whilst these do not give practical management guidelines they do give a clear insight into the thoughts and fears of our patients which may help us to approach their problems with more sympathy However it would be a mistake to assume that all AIDS patients are as articulate and well adjusted as these two authors

This is a useful and practical book which deserves to be regularly updated and preferably expanded Every doctor should have ready access to a copy and its reasonable price makes this possible

AROM

How to do it 2 British Medical Journal £6 95 inland £9 00 overseas (including postage)

How to do it 2 is a sequel to rather than an update of *How to do it* a popular little book that readers may recall sprang from a series of articles in the *BMJ* In this latest volume 35 authors give advice on dealing with situations that a doctor tends to take for granted until he becomes involved when he suddenly finds them more daunting than he had realised For example organising an examination dealing with a complaint making a video writing an obituary or dealing with a sick colleague

Each chapter is in the form of a short punchy not too serious essay by an author with experience of the topic and the whole makes for easy and enjoyable reading in bed in a train or as a passenger in a car

It is reassuring to find that even the recognised experts have their problems and the reviewer shed a great secret burden of guilt and inadequacy when he read the chapter by the very able medical author Michael O Donnell that 20 re-writes of a short article was entirely normal

This is a good book to treat yourself to in the Medical Booksellers after you have thumb marked all the expensive volumes you cannot afford or better still it is a book for your wife or children to buy for you on your birthday or at Christmas

RR

Clinical Tropical Medicine and Communicable Diseases—Volume 2

Sexually Transmitted Diseases in the Tropics Ed A O Osoba Pp 248 Bailliere Tindall W B Saunders UK £17 50 USA $28 00 Others £19 50

This remarkably compact book runs to only 248 pages including the index Since the whole spectrum of tropical STD is covered we are grateful to the Guest Editor Professor A Olu Osoba for his Foreword

There have been many advances in the management and treatment of tropical STD since R R Willcox in 1964 published the second edition of his definitive Textbook of Venereal Diseases and Treponematoses which not only included the tropical venereal diseases but also had a chapter devoted to the non venereal treponematoses This was one of the bibles for those who trained at that time and some of the photographic figures seem familiar!

But there the resemblance ends because "Sexually Transmitted Diseases in the Tropics" is very up to date as are the many black and white photographs which illustrate the clinical sections of the chapters.

Following a fascinating opening chapter on epidemiology which includes comparisons of STD prevalence between countries ranging from Saudi Arabia to Zimbabwe and comments for example on patterns of marriage and divorce and adaptive changes of pathogens the succeeding 13 chapters deal with a condition or group of conditions. The texts are clearly well laid out and with bold paragraph headings Recommended treatment regimens are clear to follow and the chapters conclude with a summary and list of references

Following AIDS in the tropics the final chapter is devoted to "Control of sexually transmitted disease in the tropics and developing countries which is of great interest and includes flow charts to illustrate management at more remote health centres In short this book is recommended reading for those doctors and medical staff who may have occasion to treat patients from tropical Africa suffering from a sexually transmitted disease In slim hardback format it deserves a place on the library shelves of every Genito-urinary Medicine Clinic

PJD

Yearbook of Anaesthesia 1987 Ed R Miller Year book Medical Publishers Inc £37 50

The Yearbook series is an American contribution to the identification of the most important published additions to the world literature in a wide range of 34 medical and surgical specialities With quite transatlantic spelling the *Yearbook of Anesthesia 1987* has examined 93 journals and selected the most interesting and relevant papers to demonstrate current anaesthetic interests and practices

One can only marvel at the industry of Dr Ronald Miller Editor and his four associate editors in covering the enormous amount of work involved Miller is well known to British anaesthetists as being

the Editor of a three-volume [illegible] on anaesthesia.

The journals which have been examined are largely of American origin [illegible] over 10% originate in the UK. Further a range of surgical, medical and pharmacological journals are present in the total rendering purely anaesthetic publications in the minority. The book is divided into 15 sections which amply cover current anaesthetic subjects of interest. It begins with a section entitled "The Informed Anesthesiologist" which presents papers covering new and topical surgical advances. It is always warming to have a wider knowledge of surgical practices than one's fellow colleagues appreciate.

Two particular sections which reflect current interest have been included. Monitoring is highly relevant today with the appearance of the concept of legally enforceable minimal monitoring standards and the rapidly changing and advancing specialty of critical care medicine is also well represented.

There are 332 digests of papers presented, many with comments made by the editors. These comments [illegible] highly individual, often assertive and never vague. Thus to the selected papers of UK origin. For example in the discussion of a paper from Leeds dealing with Spinal Hyperbaric Lignocaine for elective Caesarean section the editor states he is in complete disagreement with just about everything in the article. Other criticisms levelled at UK papers are failure to comply with protocols and dubious ethical procedures judged by US standards. However this is a fascinating book to dip into and I found it very much so.

The comments made by the editors almost entice one to read the whole book in a couple of days following the human failing that scandal is often irresistable reading.

The index is comprehensively helpful and although no substitute for Index Medicus this book could well act as a short cut to getting one on the rails regarding the provision of references for a particular subject. It would be pleased to have this volume in my hospital library.

RAM

LETTER TO THE EDITOR

Sir,

We were encouraged to see the enlightened letter by Superintending Nursing Officer H R M Schofield criticising the poor example set by the Royal Naval Medical Service on health and in particular on smoking.

Campaigning against smoking in the Royal Navy is not easy. In 1965 we wrote a paper reviewing the evidence that smoking was harmful to health including specific aspects relating to fitness of Servicemen. We also pointed out the revenue lost by HM Government through the issue of Duty Free cigarettes to Servicemen at home which amounts to an effective sponsorship for Servicemen to smoke to the tune of £3 000 000 per year. We argued that this was not sensible both in terms of health and against the background of cuts in the Defence Budget.

Regrettably after submission to this Journal the article was heavily censored and so emasculated that it became unworthy of publication.

We support whole heartedly all attempts to curtail smoking in the civilian as well as the Service population. A concerted campaign in the Service to reduce smoking and to abolish the issue of Duty Free cigarettes at home is long overdue.

Yours faithfully,

J K RAMAGE
Surgeon Lt Commander RN
Senior Registrar in Medicine

J G WILLIAMS
Surgeon Commander RN
Professor of Naval Medicine

OBITUARIES

Surgeon Captain (D) Alastair MacDonald Watson OBE RN died on 19 November 1987 at the age of 78

Surgeon Rear Admiral (D) R J S Turton writes

Alastair MacDonald Watson born in 1909 was the son of a dental surgeon. He received his early education at Sidcup Quaker School and thence Bath Grammar School. He trained at the Royal Dental Hospital, London qualifying LDS RCS Eng in 1931. After a while in civilian practice he applied to join the Royal Navy. He was accepted and joined RNH Haslar in early 1934 as a Surgeon Lieutenant (D) for the nominal New Entry Course.

He was a man of superb physique and all round games player excelling at cricket as a fast bowler. As such he played for Somerset County and the Royal Navy and became a member of the MCC.

In 1936 he was appointed to the battleship HMS *Barham*. After a spell at RNH Haslar he was posted to HMS *Tanka* Colombo in 1940 and transferred in 1942 to a Naval base being developed in Bombay. From 1943 to 1948 he served first at HMS *Victory* and then at HMS *Drake*. During the war years he attended several specialist courses in dental surgery and in 1949 proceeded to RNH Trincomalee on the staff of C-in-C East Indies. On return he served at HMS *Ganges* followed by an appointment to RNH Bighi Malta in 1954. Selected to be Deputy Director General (D) in December 1955 he was posted to the Medical Department of the Admiralty. In January 1956 he was awarded the OBE and promoted to Surgeon Captain (D) in June.

His exceptional ability was recognised by a series of specialist appointments to RNH Bighi in 1958, RNH Plymouth in 1961 and RNH Haslar in 1964. In 1965 he was graded a Consultant in Dental Surgery and in 1965 he was appointed QHDS. In 1966 he was placed on the retired list but continued working for the Royal Navy as a civilian dental practitioner at HMS *Collingwood*. Throughout his career he set himself very high standards and sought to further ever improved dental care proffered by the Dental Branch.

On retirement he launched himself wholeheartedly into civilian affairs. He became a Hampshire County councillor leading to the Chairmanship of Hampshire Council Social Services and membership of Wessex Health Authority. In education he was manager of a local primary school and Chairman of the Governors of Bay House Secondary School. Always a devout and staunch churchman he became a member of St Mary's Alverstoke, PCC and served the Church in many ways not least as Chairman of Christian Stewardship.

But tragedy struck in 1978. While attending a Test Match at Lords he became ill. His condition developed into a most serious stroke which rendered him seriously handicapped. For nine years he fought and survived this blow with courage and fortitude always with the devoted encouragement of his wife until he succumbed on 19 November 1987.

In 1940 he married Betty Thompson and together they formed an ideal partnership extending hospitality wherever they made their home. They had two sons and to them their families and to his wife Betty we who knew Alastair and mourn an admired friend and colleague extend our greatest sympathy in their loss.

Surgeon Commander Charles Edwin Drew LVO VRD FRCS RN died at his home in Roehampton on 31 May at the age of 70.

Dr Christopher W Flood writes

Charles Edwin Drew was born in 1916 and educated at Westminster City School and Kings College London. Qualifying in 1941 from Westminster Medical School and following the requisite resident posts he entered the Royal Navy as Temporary Probationary Surgeon Lieutenant RNVR. In 1943 his ship HMS *Egret* was sunk in the Mediterranean by one of the earliest radio-controlled missiles. Charles was trapped below deck but with others swam along a companionway to safety. He evidently enjoyed his naval experience and joined the London Division of the RNVR after demobilisation in 1946 where he reached the rank, rare in that ever doctored division, of Surgeon Commander and was awarded the VRD in 1950.

After demobilisation Charles joined the throng of ex-Service Doctors returning to Westminster and taking the Fellowship in 1948. He moved onto the Brompton Hospital where he was Chief Assistant to Clement Price-Thomas. He in his own forceful way persuaded Charles to initiate open heart surgery

using profound hypothermia to arrest the heart lung machines with extra-corporeal circulation became practical

The first operation for aortic aneurism was performed at Westminster by Crawford of Sweden Soon Charles had a long series of his own to his credit having been appointed as a General Surgeon to Westminster in 1952 However like so many of his work he was too busy or too involved to publish so that he never gained the credit for the pioneering work he did in the fifties and sixties to which major cardiac surgery is due and is debitable

In 1951 as part of the Westminster team he accompanied Price Thomas to the Palace for the King's pneumonectomy being made MVO (now LVO)

He was soon asked to join the staff of St George's Hospital linking those two hospitals once more Consultancies at King George V Hospital Godalming then at King Edward VII Hospital Midhurst together with the Royal Navy and the Army followed not to speak of his learned societies and travelling visits

Charles Drew was a handsome man Over six feet tall, with classical good looks he impressed in any gathering He tolerated the pompous the foolish and the garrulous not at all a pithy and distinctly audible aside more than cutting down to size He gave of his best and tolerated only the best from his medical and nursing staff but these he supported and encouraged to the full An alumnus for the Royal College of Surgeons, he was thought to be severe but marked easily and more than once indeed a candidate at the Examiner's Meeting.

It was my privilege to know Charles for nearly 50 years since I first went to Westminster as a student when Charles was the Senior RMO In later years we were near neighbours and he enjoyed the company of old friends especially if they happened to call in around noon or six o'clock. Scandalous were some of his reminiscences about his colleagues and especially of administrators

He enjoyed his garden for years taking prizes at the local garden society with his roses Trout and salmon fishing he relished but these he was not able to enjoy fully even when retired

He met his wife Doreen when she was serving in the QARNNS(R) at Queen Anne's Mansions She survives him together with their son David and daughter Sarah His family were his great joy and pride, and they in turn supported him in his last illness after laryngectomy To them we offer our sincere sympathy and our prayers

Surgeon Captain John Henry Brunell Crosbie CBE RN died on 26 October 1967 at the age of 90 at his home in Scotland

John Crosbie was born in Kells in the Republic of Ireland on 6 October 1877 and qualified at Trinity College Dublin in 1900 an event which had been somewhat delayed due to World War I during which he saw temporary war service as a Surgeon Probationer RNVR with HMS *Orbit* between October 1916 and January 1918 Following his betand qualification he joined the Navy as a Surgeon Lieutenant in February 1921

He was promoted Surgeon Lieutenant Commander in February 1927 and Surgeon Commander in February 1933 Following this he served for some time in HMHS *Maori* where he was appointed as Ophthalmic Specialist In January 1941 he was appointed to HMS *Romilies* as Squadron Medical Officer a post which he held until September 1942 when for a short time he was appointed to the RN Auxiliary Hospital Southport and then to HMS *Britannia* where he was Principal Medical Officer at the Cadet's Sick Quarters at RN College Eaton in Cheshire

On promotion to Surgeon Captain in June 1944 he was appointed to the Staff of Commander in Chief Home Fleet as Fleet Medical Officer following which he was appointed as Medical Officer in Charge RN Sick Quarters Shotley a post he held until October 1946 His final appointment was to HMS *Daedalus* as Staff Medical Officer to Flag Officer Air (Home) during which time he was appointed KHP and later reappointed QHP He retired from the Royal Navy in October 1954 and was awarded the CBE in 1955

He is survived by his widow to whom we extend our deepest sympathy

A further appointment of **Surgeon Rear Admiral D P Gard CB** has been received from Surgeon Captain H J A Hahn RN

I first met Dudley Gard at RNH Stonehouse in 1958 I was serving with the Royal Marines at the time and had aspirations to become an Ophthalmologist Dudley was most helpful in teaching me the elements of the subject in his free time once a week and arranged for me to go to Haslar the following year as his trainee

This was the start of a friendship that was to last 29 years A true gentle philosopher and friend to all who worked under him he was always ready to give helpful advice on the clinical subject he knew and loved so well and also on Service matters of which he had a deep understanding. I spent two and a half happy years as Eye Specialist in Malta during Dudley Gard's time as SMA Flight and came to know him and Theresa very well Their hospitality and their interest in the social life of the Medical Mess was outstanding. Dudley was noted for his ability as an after dinner raconteur He had a fund of hilarious stories with which he often entertained us at Flight Mess Dinners

His kindness coupled with a dry sense of humour could be very reassuring. I remember an occasion long ago when I had made an administrative blunder which incurred the wrath of the powers-that-be I went and reported the matter to Dudley in his office He said little but picked up the telephone and dismissed me from the room A little while later I was recalled and he fixed me with a look of mock severity 'You had better pray' he said 'but don't pray too hard I think I spy land ahead' Soon I learned from

the Service. Dudley Gurd's friendship and good counsel have always been a strong support to me and to younger members of my family as well.

His tragic death has cast a dark shadow over all those who loved him.

Surgeon Captain Patrick O'Brien RN died October 1987 at the age of 77.

Patrick O'Brien was born in 1910 and educated at the Capuchin College, Rochestown, County Cork and Rockwell College, graduating in medicine at Trinity College, Dublin in 1934.

In January 1938 he joined the Royal Navy as a Surgeon Lieutenant and a year later was posted to the China Station during the Sino-Japanese war.

At the outbreak of World War II he was transferred to the Mediterranean where he served until July 1942. In that month his ship, HMS *Defender* was sunk off Tobruk and Patrick, along with his fellow survivors, was taken to Alexandria.

He was present at the decisive battle of Matapan and mentioned in despatches. Subsequently he experienced the excitement of accompanying a North Atlantic convoy.

After the War he served at stations in Singapore, Hong Kong, Malaysia, India, Simonstown, Valetta and Trincomalee. In 1956 he was recalled from Trincomalee to join the Royal Yacht *Britannia* for a Commonwealth tour.

In the early 1960s he served in the Royal Naval Hospital in Valetta and on his return from Malta was appointed to the Royal Naval Hospital at Plymouth, later becoming a consultant at Invicta Park at Maidstone in Kent.

He retired in 1979 and returned to Ireland where he resided until his death.

He was totally unaffected by his distinguished career and remarkable experiences. Throughout his long life his strong faith was unwavering and his feeling for his own people and place touching.

Surgeon Commander Ellis Hughes Parkinson VRD RNVR died on 7 October 1987 at his home in Weymouth at the age of 83.

Ellis Hughes Parkinson graduated in medicine at Birmingham University in 1929 and joined the Royal Hospital, Wolverhampton as house surgeon. He entered General Practice in Portsmouth and then in 1932 bought a practice of his own in Wyke Regis. Having been in the Royal Naval Volunteer Reserve since his student days, he was among the first to be called up when war broke out. He was Senior Medical Officer in the armed merchant HMS *Furious* for two years, during which time he had several close shaves including crashing into the sea when a Swordfish in which he was flying overshot the flight deck.

In 1942 he was posted to St Merryn Fleet Air Arm station near Padstow where he stayed until 1944. He was demobilised in 1946 in the rank of Surgeon Lieutenant Commander and returned to his practice in Wyke Regis which had all but disappeared. When he retired in 1965 it was a thriving three-man partnership.

He was active in medical politics being secretary to the Dorset division of the BMA for 25 years and representing it at the annual conference on many occasions.

His wife Marjorie predeceased him by a few months. He is survived by his two sons Jeremy who followed his father into general practice at Wyke Regis and Nigel, to whom we extend our deepest sympathy.

We have recently learnt of the deaths of **Surgeon Commander (D) W E A (Bill) Watson RN** on 30 October 1987 and of **Surgeon Captain T G B Crawford RN** on 13 January 1988. Any personal reminiscences will be welcomed by the Editor.

We have also learnt of the death of **Surgeon Captain R W B Scott RN** on 4 December 1987. An obituary is to be published in the next issue.

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SERVICE NEWS

ROYAL NAVAL MEDICAL AND DENTAL OFFICERS

HONOURS

The Most Venerable Order of the Hospital of St John of Jerusalem

Officer (Brother)
Surgeon Captain J M Young

APPOINTMENTS AND PROMOTIONS

To Surgeon Vice Admiral and appointed Surgeon General
1 January 1989
G J Milton Thompson QHP

To Surgeon Rear Admiral (D) and appointed Director of Defence Dental Services
1 January 1988
D A Coppock QHDS

As Consultant Adviser in General Surgery to Medical Director General (Naval)
1 January 1988
Surgeon Commander R J Leicester

As Professor of Naval Surgery
1 January 1988
Surgeon Commander I L Jenkins

As Professor of Naval Medicine
1 January 1988
Surgeon Lieutenant Commander R H Taylor

To Surgeon Captain
D C Whyte

To Surgeon Commander
D G Bruce J F Gabb J I C Hogg M D Simmons

To Surgeon Commander (D)
D C C Alexander

To Surgeon Lieutenant Commander
G M Barker M E de Bhulbh A A R Mostyn

To Surgeon Lieutenant Commander (D)
P F Culwick S E Howe D R Webber

Provisional selections for promotion to date 30 June 1988

To Surgeon Captain
D M Crean K H Sugars

To Surgeon Commander
D W Somerville M J Fox P Litchfield A R O Miller

To Surgeon Commander (D)
J H Barker

AWARDS

The Gilbert Blane Medal for 1987 has been awarded to Surgeon Commander G H G McMillan

The prize for the best student from the Society of Occupational Medicine has been awarded to Surgeon Commander F I Raffaelli

CONSULTANTS SENIOR SPECIALISTS AND SPECIALISTS

The following professional advancements are announced

Consultants

Accident and Emergency Medicine
Surgeon Commander I C Grant

Occupational Medicine
Surgeon Commander J J W Sykes

Anaesthesia
Surgeon Commander R A Moody

Senior Specialists

Occupational Medicine
Surgeon Commander G M F Woodroof

General Surgery
Surgeon Lieutenant Commander C P G Barker

Oral Surgery/Oral Medicine
Surgeon Lieutenant Commander (D) R C Sanderson

Specialists

Applied Physiology
Surgeon Commander D J Baker

Ophthalmology
Surgeon Lieutenant Commander M N Jeffrys

Occupational Medicine
Surgeon Lieutenant Commander C J Stoot

HIGHER QUALIFICATIONS

Surgeon Commander G H G McMillan—FRCP(Glasg)
Surgeon Commander (D) J G Iles—MSc (Community Dental Health)
Surgeon Commander F I Raffaelli—MSc (Occupational Medicine)
Surgeon Lieutenant Commander (D) J H Harker—MSc (Conservative Dentistry)
Surgeon Lieutenant (D) S J Liggins—FDS

TRANSFER TO FULL CAREER COMMISSION

Surgeon Commander C D Houghton

NEW ENTRIES

Surgeon Lieutenant C J A Edwards
Surgeon Lieutenant (D) M A Cottrell
Acting Surgeon Lieutenant R H Keen
Surgeon Sub-Lieutenants (Miss) L S Davies R M Hayes P E Howden P W King Lewis R Myles, (Miss) S A Stapley M S Turner (Miss) S A L Whiter
Surgeon Sub Lieutenant (D) C R D Fox

PLACED ON EMERGENCY LIST

Surgeon Lieutenant Commander M E de Rhalloh
Surgeon Lieutenant Commander S P L Travis
Surgeon Lieutenant Commander (D) N J Poppelwell
Surgeon Lieutenant C W R W Anandar
Surgeon Lieutenant J M Neary
Surgeon Lieutenant (D) P T J Robinson

RETIREMENTS

Surgeon Captain T F Oliver
Surgeon Lieutenant Commander G W L Evans (O/R)
Surgeon Lieutenant A P L Goodwin (O/R)

MEDICAL SERVICES

HONOURS

The Most Venerable Order of the Hospital of St John of Jerusalem

Officer (Brother)
Medical Assistant K Shore

Serving Brother
Lieutenant M Raven

The above photograph taken at a farewell lunch held at Royal Naval Hospital Plymouth for Miss Jenny Huddy Personal Assistant to the Medical Officer in Charge, for many years shows six previous MOICs four of them Admirals
From left to right (Standing) Surgeon Rear Admiral G A Binns CB Surgeon Rear Admiral J M Houghton MVO Surgeon Rear Admiral J Cox OBE Miss J Finn Mrs J Nicholls and Miss J Greenwood (personal friends of Miss Huddy) Surgeon Captain J A M Wright RN Second Officer D E M Britten WRNS (MOIC's Secretary) (Seated) Chief Nursing Officer V Fisher QARNNS Matron RNH Plymouth Surgeon Rear Admiral T R W Hampton QHP Miss Jenny Huddy Surgeon Captain A Revell RN

NEW YEAR HONOURS 1988

British Empire Medal
Medical Technicium 1 (L) P O Callaghan

AWARDS

The Sick Berth Petty Officer's Medal for 1987
has been awarded to
Petty Officer Medical Assistant T D McAuslin

Sub Lieutenant (MS) D C Steel RN receiving the Cunningham Sword for the Best Non Seaman Candidate of 1986 from Admiral Sandy Woodward at the Passing Out Parade at Britannia Royal Naval College, Dartmouth on 30 July 1987

PROMOTIONS

To Lieutenant Commander (MS)
F Reed

To Lieutenant (SL)(MT)
(*Since transferred to SD (MS) List*)
B Brickie M E B Genevieve R J Hollyoak S McKinley L W Smith

To Lieutenant (MS)
M A White

To Sub Lieutenant (SL)(MT)
(*Since transferred to SD (MS) List*)
J W Alfano

To Chief Petty Officer Medical Assistant
S Bannister R H Lockhart T M McAuslin D Munn K Penman G C Till J B Williams

To Chief Medical Technician
D J B Freer D A Griffiths R G McGrann

QUEEN ALEXANDRA'S ROYAL NAVAL NURSING SERVICE

NEW YEAR HONOURS 1988

Member of the Royal Red Cross
Principal Nursing Officer M E Williams

Associate of the Royal Red Cross
Chief Nursing Officer V C Fisher
Superintending Nursing Officer E M Weall

PROMOTIONS

To Superintending Nursing Officer
Miss J D Beach Mrs I J Butcher Miss A L Robertson

To Senior Nursing Officer
G E Watkinson

To Chief Petty Officer Registered General Nurse
C J Hall J M Lennon E A Watson

TRANSFERS TO MEDIUM CAREER COMMISSION

Superintending Nursing Officer J Bancroft
Senior Nursing Officer S Cronghan

NEW ENTRIES

Senior Nursing Officer R M Duke
Nursing Officer L Bryan
Nursing Officer M N Harvey

ROYAL NAVAL RESERVE

HONOURS

Member of the Most Venerable Order of the Hospital of St John of Jerusalem

Officer (Brother)
Surgeon Captain (D) H Cantrill RD
(*Prendutt*)

PROMOTIONS

To Surgeon Lieutenant Commander
G H Birtholomew (*Mercia*)
D J Makepeace (*Eagle*)
G M Spencer (*Sherwood*)

To Surgeon Lieutenant
D J Campbell (*Windrush*)
A M Davison (*Cervi*)
M W English (*Paragon*)

To Surgeon Lieutenant (D)
M J Keogh (*Prendutt*)

Three Medical Officers gathered together at the Royal Naval Medical School. The current Medical Officers Commanders (from left to right) Commander W. Scott MSc RN, Commander H.R. Hughes RN (retired) and Commander D.E. Shone RN.

NEW ENTRIES

Surgeon Lieutenant Commander D R J Gleuning (*Eagle*)
Acting Surgeon Lieutenant J F Lancaster (*Rhyl Fox*)

RETIREMENTS

Surgeon Lieutenant Commander J E M Fox (*Mercia*)

The Quatercentenary of Trinity College Dublin

The Quatercentenary of Trinity College Dublin takes place in 1992. It has been suggested that the Medical School should compile a history of the school over the past four hundred years. Medical Officers among our many subscribers who graduated from Trinity are requested to forward brief details of their careers both within and outwith the Service to:

The Dean
Faculty of Health Sciences
Trinity College
Dublin 2
Ireland

ARE YOU CORRECTLY ADDRESSED?

The names and addresses of subscribers to the Journal of the Royal Naval Medical Service are currently being transcribed from a card index system to a computer database which it is hoped will be easier to maintain. In order to ensure that this database is as far as possible kept up to date, subscribers whose address details are at present incorrect are invited to complete the tear off form below and return it to the Editorial Secretary. The form may also be used to notify future changes of address.

To: Editorial Secretary, Journal of the Royal Naval Medical Service, Mouckton House, Alverstoke, Gosport, Hants PO12 2DL.

Please note my correct*/new* address.

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RANK/TITLE

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Town

County Postcode

Signed Date

* Delete as appropriate

No 2 Summer 1888 Vol 74

JOURNAL of the ROYAL NAVAL MEDICAL SERVICE

 ISSN 0035 9033

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Notice to Authors

Contributions should be submitted to the Editor, Journal of the Royal Naval Medical Service, Institute of Naval Medicine, Alverstoke, Hants PO12 2DL, who will arrange for any necessary security clearance. The attention of Medical Branch personnel is drawn to the provisions of QRRN Appendix 35 J.

Manuscripts should be prepared in the Vancouver style. They should be typewritten with double spacing and wide margins and should include title page, abstract (of not more than 150 words), introduction, method, results, discussion and references, each section commencing on a separate page. A convenient length is between 2000 and 3500 words, plus essential tables or illustrations.

Tables and illustrations should be referred to in the text. Tables should be typed in double spacing on separate sheets. Figures should be professionally drawn, making due allowance for the appropriate reduction. Glossy black and white photographs should be submitted unmounted whenever possible. Titles and detailed explanations should be given in the legends which should be typed on a separate sheet.

References should be numbered consecutively in the order in which they are first mentioned in the text. At the end of the article the full list of references should given the names and initials of all authors (unless more than six, when only the first three should be given, followed by *et al*.). The authors' names are followed by the title of the article, the title of the journal abbreviated according to the style of *Index Medicus*, year of publication, volume number and first and last page numbers. Titles of books should be followed by the place of publication, the publisher, and the year, e.g.

> Soter NA, Wasserman SI, Austen KF. Cold urticaria, release into the circulation of histamine and eosinophil chemotaxin factor of anaphylaxis during cold challenge. *N Engl J Med* 1976; **294**: 687–90.
> Osler AG. *Complement: mechanism and function*. Englewood Cliffs: Prentice-Hall, 1976.

1 The Vancouver style. *J Urol Nephrol Nurs* 1979; **65**: 179.
2 International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. *Br Med J* 1982; **284**: 1766–70.

NOTICE

The Journal of the Royal Naval Medical Service is published three times a year (in March, July and November) one volume comprising three issues. The rates of subscription are:

1 RN and RNR medical and dental personnel on the active or retired list, Consultants to the Royal Navy, Medical Service officers and ratings and members of the QARNNS—£8·00 per annum post free (single copies £2·80).

2 RN and RNR personnel on the retired list aged 65 years and over and who have subscribed continuously for 20 years or more—£5·00 per annum post free (single copies £2·00).

3 All others not in the above categories—£10·00 per annum post free.

All communications relating to subscriptions and notifications of change of address should be forwarded to the **Editorial Secretary, Monckton House, Institute of Naval Medicine, Alverstoke, Hants PO12 2DL.**

NOTICE TO ADVERTISERS

Space orders should be sent to Combined Service Publications Ltd, P O Box 4, Farnborough, Hampshire GU14 7LR. Blanks and/or Copy should be forwarded to the same address to arrive by the first day of the month preceding issue publication dates being March, July and November.

Advertising Rates and Technical Details are as listed in British Rate and Data.

HMS Superb surfaced in a polynia at the North Pole

This edition of the Journal of the Royal Naval Medical Service has been devoted to Submarine Medicine With the use of a Nuclear Power Source in submarines, the requirement to come to the surface at frequent intervals disappeared The submarine could move further faster and deeper and the days of burning oxygen candles were over The role of the Medical Officer and the Medical Scientist grew immediately The atmosphere had to be meticulously controlled radioactivity monitored and the sick treated far away from Naval Hospitals In this Journal some of the current problems and their solutions are described

The Editor is particularly grateful to Rear Admiral F F Grenier Flag Officer Submarines for providing the Foreword and to Surgeon Captain D J McKay the Submarine Flotilla Medical Officer for his assistance in co-ordinating contributions

Foreword

by Flag Officer Submarines, Rear Admiral P F Grenier

It is with some surprise and not a little pleasure that I find myself writing in this Journal The Medical Branch is now well established in the submarine world and the appearance of the now familiar Dolphins on many a medical breast is taken for granted I remember with much affection the first distinguished Medical Officer to gain his Dolphins Roger Lambert who climbed the tree to become Medical Director General Doctors have had involvement in submarines since early days. In 1620 Cornelis Drebbel a Dutch physician who had long resided in England began to delight Londoners with submarine displays He built three at least and earned the title of The Father of Submarines' The largest contained twelve rowers and still had room for passengers It is claimed that King James 1st allowed himself to be conveyed in this manner the few miles from Westminster to Greenwich Perhaps this is unlikely in view of the Kings notorious physical cowardice but it is true he was an enthusiastic patron of Drebbels

Elsewhere in this Journal the essential role played by the Medical Branch in the Submarine Flotilla at sea and in support is described I must also acknowledge the equally important front line support provided by our Hospitals and the 'Back Room Boys' in research and development This is the era where due to advances in technology Stoneage man is being crammed into space age machinery! The flotilla continues to grow in size and the task at sea increases by the year New classes of submarine materials and equipment require the best medical expertise if we are not to damage ourselves and end up deaf blind lame poisoned or mad The occupational health support to this end must long continue if we are to keep up with the hunt As a permanent member of the Royal Naval Personnel Research Committee of the Medical Research Council and a non-medical man my awareness of the work being carried out on preserving health and habitability in submarines is kept sharp

The Medical Branch in submarines is not alone in having manpower problems but I am aware that MDG(N) is working towards a solution which should produce more efficient and better structured medical support for the flotilla without detriment to the straight medical role of the MA at sea—thereby maintaining the excellent record of never having had to abort a patrol for medical reasons It is a pleasure to record my appreciation for all the service given by the Medical Branch to the Submarine Flotilla.

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The Submarine Medical Officer

In the Autumn of 1958 Surgeon Lieutenants PAUL and LAMBERT joined HMS ACHERON and were destined to become the first Submarine Medical Officers in the Royal Navy

The introduction of nuclear powered submarines into the Fleet greatly expanded its operational capability It also meant that these submarines would be away from base for much longer periods than had been previously possible and at greater distances This in itself caused some concern in terms of medical support but additionally there was the problem of power plant the potential medical hazards of which had not been fully established Thus a need was created to have medical officers specifically for these submarines

The intrepid two left ACHERON to join the submarine officers course at HMS DOLPHIN On completion in April 1959 they crossed the Atlantic to spend six months with the US Navy on board the USS NAUTILUS SKIPJACK and SKATE

They returned to Greenwich for a year of nuclear training and in 1960 Surgeon Lieutenant Lambert later to be Surgeon Vice-Admiral Lambert became the Medical Officer of HMS DREADNOUGHT the first Submarine Medical Officer in the Royal Navy

Five years later the next batch of Medical Officers commenced training with the view to joining the new Resolution Class Ballistic Missile Submarine (SSBN) Since then there has been a steady flow of doctors entering the Submarine Service primarily for SSBNs but occasionally for the hunter killer submarines (SSNs)

Today the post of Submarine Medical Officer (MOSM) is one of the most challenging appointments in the Royal Navy and provides a unique opportunity to experience the Navys' "Sharp End"

Training for MOSMs commences with a month's course at HMS DOLPHIN This is a general course for all nuclear submarine officers (except engineers) and covers the basic operating principles behind the two nuclear submarine systems ranging from high pressure air to garbage disposal[1] The course is divided up into classes according to which type of boat to which the Officer has provisionally been assigned The final of Part I (after the exams) is a two day session of escape training, culminating in a simulated escape from thirty metres Soaring up through a hundred feet of water in a dayglo orange escape suit is an exhilarating experience not to be forgotten

The next stage of training takes place in the hallowed halls of the Royal Naval College at Greenwich and involves the nuclear systems of submarines Up to two years ago Medical Officers did the same course as other officers They now undergo an intensive but intellectually stimulating training programme with more emphasis on reactor chemistry nuclear physics radiological protection and slightly less on reactor operations Trainees are able to get Hands On experience driving a small nuclear reactor and handling a range of monitoring equipment all of which they will be expected to use at sea There is also a reactor control room simulator for each class of nuclear submarine This is used to demonstrate the normal working procedures associated with the reactor and to generate various accident scenarios showing the

Surgeon Lieutenant Smith is Deputy Squadron Medical Officer 2nd Submarine Squadron Naval Base Plymouth

appropriate corrective measures that can be taken Tabletop exercises give further insight into the problems associated with a full scale nuclear accident

The training continues at the Institute of Naval Medicine with a four week course that reinforces the practical aspects of nuclear chemistry and radiological protection taught at Greenwich, as well as covering the basic concepts of atmospheric control This concludes 'Part 2' of the submarine training programme

Fasdane is the final port of call before the MOSMs eventually join their submarines During this week the trainees become acquainted with the various hazards associated with the Polaris missile system

Brain overflowing with theoretical knowledge of submarine systems the doctor now joins his submarine to complete his training known as the 'Part 3' As with the 'Part 1' the 'Part 3' is common to all officers It involves the practical application of all the knowledge obtained so far gaining an intimate understanding of the layout of systems within the submarine how they are operated in normal and emergency situations Much time is spent in overalls crawling around the plethora of dark inaccessible corners found in a submarine identifying the various components of each system It takes an average twelve weeks to pass the final board to earn the coveted dolphins

Whilst at sea the Medical Officer can expect to see an average of no more than three or four fresh cases per day consequently he can become more heavily involved in the day to day running of the submarine

On Resolution Class submarines (SSBN) the MO has a multitude of tasks Not only does he keep control room watches but he is the Education Officer Film Officer and Wardroom Wine Caterer If qualified he may also become the diving Officer

The MO serving on Fleet Class submarine (SSN) finds himself in the control room watch This is much more involved than keeping watches on an SSBN due to the type of operations undertaken by this type of submarine and twelve hours per day are spent working in the control room

SSBNs are blessed with the luxury of a small sickbay (basically a bunk and some storage space) whereas on SSNs a bunk is taken over as required and patients are seen wherever a quiet space can be found

Submarines are able to carry a wide range of pharmacopoeia the limitations on space only becoming noticeable with the larger items of equipment Parenteral anaesthetics are used as volatile anaesthetics constitute a potential atmospheric hazard

The main difference between medicine on submarines when compared with surface ships is the lack of access to diagnostic facilities and the ability to rapidly evacuate casualties The most sophisticated pieces of medical equipment carried are an haemoglobinometer and a microscope samples can't be sent off in the post as it may be as long as three months before a submarine can send or receive mail As a result the Submarine Medical Officer learns to become much more self-reliant and has to develop basic medical techniques to their utmost employing treatment regimes requiring ingenuity and innovation

To interrupt a patrol on medical grounds you have to present a very strong case Before a decision can be made all the consequentes of the options available have to be carefully weighed up For example appendicitis can usually be treated conservatively on board with antibiotics Of note is that a torted testis has been successfully operated on during a patrol

When considering evacuating a patient the method must be thoughtfully considered Is it safer to wait and transfer the patient across the brow or is the case serious enough to warrant a helo transfer? Anyone who has ever seen a submarine on the surface in rough weather will appreciate how dangerous the latter option can be

In the early days submarines were fraught with danger An engineer on one of the infamous K boats is said to have contacted the control room with the message 'My ends diving what's your end doing?' Thankfully things have improved since then but certain manoeuvres still remain hazardous particularly diving and surfacing

Because it is vitally important for the safe operation of a submarine every member of its ships company must be totally familiar with the operating systems and safety drills The Submarine Medical Officer has a much more detailed knowledge of the tasks carried out onboard than his surface fleet counterpart This understanding of individual tasks enables the medical staff to make a much more comprehensive assessment of limitations to an individual due to an illness or injury

The majority of cases seen at sea involve the skin or upper respiratory tract however more

exotic problems do occur from time to time. For example within the Second Submarine Squadron over the past year problems have ranged from diabetes to electrocution.

The submarine world has an enormous potential for research. It represents a unique environment which is a totally closed system and all environmental parameters can be observed and recorded. Present projects include investigation of bacterial populations, alteration of vitamin D metabolism during patrols and changes in cardiac conduction in varied atmospheric conditions.

The task of the Submarine Medical Officer is highly demanding yet ultimately rewarding. It requires adaptability and the capacity to apply medical principles in volatile situations where medical requirements cannot necessarily be afforded the highest priority. He finally becomes accepted as part of a highly trained team in a fully operational section of the Navy.

Surgeon Lieutenant M S SMITH

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The Submarine Medical Branch Rating

Around 1960 a handful of Sick Berth Attendants from the X Ray Physiotherapy and Laboratory specialisations were chosen to be trained in the skills necessary for medical staff employed in Nuclear Submarines Following a visit to the American Navy and courses at HMS DOLPHIN and the Institute of Naval Medicine, Alverstoke they became the forerunner of the present Medical Assistant (SM)

When the Medical Branch was restructured into Medical Technicians and Medical Assistants submarine medical staff were categorised as either Medical Technicians (HP) or Medical Assistants (SM) On successful completion of the Stage One course at the Institute of Naval Medicine MT(HP)s were awarded a City and Guilds Stage One Certificate in Radiation Protection and then went to sea for practical experience After approximately two years they returned to Alverstoke for the City and Guilds Stage II course The MA(SM) also undertook the Stage One course and acquired the City and Guilds Certificate but unless he transferred to the MT streamline he did not return to Alverstoke for the Stage II course

In 1972 the MT(HP) status was withdrawn and MT's were given the option to either recategorise into one of the other MT categories or to remain as MT(HP) in submarines until Time Expired

Today there are 108 Medical Branch ratings employed in the submarine service

Warrant Officers	3
Senior Ratings	49 (CPO 23 FO 26)
Junior Ratings	56 (LMA 43 MA 13)

The Medical Assistant selected for Submarine Service is initially drafted to HMS DOLPHIN for six weeks Part I training. During the first two weeks he studies all the basic non Nuclear submarine systems The last four weeks are spent learning about the particular class of submarines to which he has been assigned During the six weeks the MA undergoes his escape training, culminating in controlled exits from an escape tower and several ascents from 30 60 and 100 feet of water in "The Tank" at HMS DOLPHIN

Part II training consists of a ten week course at Alverstoke where the MA learns about the Nuclear and Environmental aspects Reactor Plant design basic Nuclear Physics Radiation Protection and Radiochemistry He is also instructed in Atmosphere Control Atmospheric Contaminants the various limits to be applied removal of toxic gases production of oxygen and environmental monitoring using the Wet Bulb Globe Thermometer Successful completion of this part of the course entitles him to the City and Guilds Stage I Certificate in Radiation Protection

He then joins the Base Environmental Support Department at either HMS DEFIANCE or HMS NEPTUNE for a two week practical application course During this period he familiarises himself with the submarines alongside, consolidates and puts into practice as much of his new theoretical knowledge as possible learns about the Base Environmental Support Department routines and completes a Task Book An oral examination board completes his Part II training and a seagoing Submarine and Part III training awaits him

The Part III trainee is expected to be a useful working member of the Environmental Department on board nevertheless he is still on a steep learning curve All his theoretical knowledge of submarine systems gained at HMS DOLPHIN must now be realised and demonstrated practically Many hours are spent crawling around machinery spaces tracing different types of pipework and electrical runs studying valve line-ups and most importantly, being thor

oughly conversant with all routine and emergency systems and procedures. After about twelve weeks he should be ready to sit the 'final board' that marks the end of his Part III training. If successful he is awarded the coveted set of 'Dolphins' and is a proper Submariner with all the history traditions and camaraderie associated with this elite group of professionals.

The medical complements of Nuclear submarines are as follows:

SSBN (Polaris)	1 Medical Officer 1 Senior Rating 1 Junior Rating
SSN (Hunter Killer)	1 Senior Rating 2 Junior Ratings

The main tasks at sea common to all classes of Nuclear submarines can be covered by four main headings: Medical Care and Preventive Medicine, Radiation Protection, Radiochemistry and Environmental Control.

Radiation Protection covers all radiation surveys which prove the integrity of the reactor shielding and contamination surveys which ensure that the submarine atmosphere and compartments remain free of radioactive contamination.

Radiochemistry is carried out at least once daily on the reactor cooling water to monitor the status and operation of the reactor core. Other chemical analyses are carried out on non-radioactive water systems. All analyses are carried out in the specially fitted Health Physics Laboratory.

Environmental control means just that. By means of a Central Atmosphere Monitor and a wide range of portable instruments frequent analyses are made of the constituent gases in the submarine's atmosphere. The POMA(SM) is responsible for advising the Marine Engineering Officer in the operation of air purification equipment, a task which includes monitoring the efficiencies of special equipment, and recommending what ancillary equipment should be brought on line.

Medical Care in the submarine world can mean anything and everything. In SSBN's (Polaris submarines) there is the luxury not only of having a small sick bay but also a Medical Officer. In SSN's a Medical Officer is carried only on particularly long or designated patrols. Most of the time at sea on the submarine the medical rating has to be self sufficient and independent. This can be an awesome responsability when not only the facility of a boat transfer but sometimes even communication with the outside world is not readily available. Confining someone to his bunk with the attendant treatment, feeding and toilet problems can be a real test of ingenuity.

In addition to the four main tasks already mentioned there are several other roles required of the medical rating. As the Health Physics Laboratory in all submarines is the only light tight compartment with running water etc. the medical staff often act as the submarine's photographic team. Taking, developing and printing photographs on some deployments can be a rewarding and interesting involvement. Medical junior ratings also become planesmen actually steering the submarine through the deep! The medical senior rate besides becoming a planesman can also carry out important Ship Control Officer of the Watch duties in the Control Room. The more business-minded are also frequently involved in running the submarine's canteen.

The medical staff are often called upon to act as a 'father confessor'. A knock on the HP Laboratory door usually in the middle of working out a particularly knotty problem.. a query 'Got a minute Doc?' and your concentration is away. An hour or so later one walks a man happier for the fact that someone listened to him getting something off his chest and impressed by the range of expertise and professionalism his 'Doc' displayed. The trust a submarine has in its medical staff both in a professional and 'in confidence' aspect is extremely gratifying and is an important aspect of close-knit submarine life.

No other draft including frigates where there is no isolation from the outside world makes a medical rating more reliant on his own overall training and knowledge than the submarine world. Sea-going drafts are divided between submarines based at Faslane and Devonport. Occasionally a medical rating is required to sail in an SSK (conventional) submarine for a special deployment which serves to highlight yet again the value of the MA's in the submarine fleet. Shore drafts can be in the Base Environmental Support Departments in Devonport or Faslane, RN Sick Quarters, the Institute of Naval Medicine Alverstoke or at the Submarine Escape Training Tank HMS DOLPHIN. The job is technical but fulfilling hard work yet exciting very professional and great fun. The extra money is a bonus.

R M EVANS

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Lighting in Submarines

D C Brown

Abstract

Since the Second World War the standard night time illumination in RN submarine control rooms and adjacent spaces has been red lighting, because of its perceived advantage in dark adaption. Red light is however unpopular and has been shown to be detrimental to the performance of other control room tasks. In recent years evidence has emerged from the United States and other Navies that the advantage of red lighting over white lighting in terms of dark adaptation is insignificant at very low intensities. In this paper the research literature is reviewed and the findings related to current lighting practice in RN submarines. At the low levels of control room night illumination there is minimal practical difference in the time taken for the periscope operator to dark adapt between red and white lighting. In view of the benefits to morale and performance offered by low level white lighting it should replace red lighting for night use in submarine control rooms.

INTRODUCTION

The use of Red Lighting to achieve dark adaptation at night was instituted in World War Two when an immense amount of scientific information was generated on the whole subject of dark adaptation. A particular problem was the provision of a satisfactory form of submarine lighting. Submarines were powered by electric batteries when submerged and had to surface each night to recharge batteries. Whilst on the surface lookout had to be kept for enemy ships and it was necessary for watchkeepers to be dark adapted before coming on deck. Similarly while submerged at night there was always the danger of a sudden emergency surfacing requiring those on watch to maintain some degree of dark adaptation as well as having enough light to carry out their normal tasks. Relatively crude experiments showed red lighting provided a considerable degree of dark adaptation compared to white and it was adopted universally in submarines as well as in many other military applications.

Since that time although the military requirement for red lighting has waxed and waned with the improvement in electronic detection adequate night vision has remained a requirement for submariners where the periscope is still one of the prime means of information gathering. Recently the level of benefit of red lighting on night vision compared to low level white light has come into question as research has shown red lighting to be unpopular and detrimental to the performance of other tasks.

Surgeon Commander Brown is currently the Naval Medical Officer of Health (Fleet).

DISADVANTAGES OF RED LIGHTING

Red lighting has long been known to be generally unpopular amongst submarine crew members causing some perceived fatigue and many complaints of eyestrain. This is thought to be due to long wavelengths producing some actual physical discomfort and visual degradation as they require more accommodation to focus them on the retina, which could prove uncomfortable for older and far sighted men. There is some speculation that it may be detrimental to the body's adaptation to a six hour watch system, as a cycle of 12 hours white and 12 hours red lighting does not coincide with the man's activities. Furthermore colour discrimination is adversely affected and this leads to difficulty in reading colour coded charts and the multicolour visual display units which are becoming increasingly common in submarine control rooms. Red lighting is normally pro-

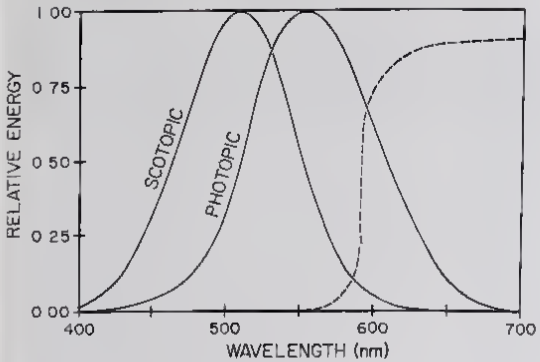

Fig 1 Luminosity curves of the human eye in arbitrary units with a maximum sensitivity set to 1 The dashed line shows a typical red filter with a sharp cut-off at around 590 nm

vided by filtering white light at n considemble power loss which is inefficient and could bc of importance in submarines running on batter ies [2]

The situation of periscopes in the control room and the need for dark adaption by the commanding officer and watchkeeping officers mean n large number of the crew are constantly exposed to red light The use by individuals of red goggles and eye patches although effective is neither an acceptable nor particularly practical solution There is therefore, a need to reassess submarine night illumination

CHARACTERISTICS OF THE EYE

The retina of the eye consists of two sets of receptors, rods and cones Rods are found mainly at the periphery of the retina and contain a special pigment known as rhodopsin which undergoes marked isomeric reorganisation when exposed to light Cones are found in greater numbers towards the centre of the retina, which itself consists entirely of cones Nerve fibres run from both to the brain the nerve fibres of rods becoming much more interconnected than those of cones as they proceed towards the brain These differences cause the rods to be functionally more sensitive to dim light than the cones although they are much less able to discriminate fine detail

The centre of the eye can discriminate fine detail in bright light but does not function in dim light the cones being unable to function at light levels below 0 1 and 0 01 ml Below this level vision is dependent on rods and it is impossible to look directly at an object since they are concentrated at the periphery of the retina with the result that fine detail is missing. Rods also have a different sensitivity to various light wavelengths than cones specifically they are less sensitive to the long (red) wavelengths. This is demonstrated by the difference between human photopic (daylight) and scotopic (night) luminosity curves which show that when the intensity of the ambient illumination decreases, the wavelengths to which the eye is most sensitive change, being 555 nm in daylight and 505 nm at night-time levels of illumination (*Fig* 1)

The eye is able to develop an increased ability to see dimly lit objects permitting it to function

through a vast range of light intensities of the order of factor 10. This process is known as dark adaptation and can continue for two hours though change is minimal after 45 minutes. As dark adaptation develops the point of maximum sensitivity moves from the centre of the eye to the periphery with a sharp decline in visual acuity, a shift in sensitivity to shorter wavelengths and a loss of colour vision. Dark adaptation is a reversible process. light adaptation being much faster though not instantaneous the time depending on the intensity and the duration of the light. For practical purposes, destruction of dark adaptation takes place after 5 minutes exposure to ordinary room lighting.[2] The process of dark adaptation is characterised by two different but parallel processes a neural mechanical action and a chemical action. The neural action is short-lasting but has a sensitivity range of only 10^3 or 10^4 and is independent of colour. The latter chemical process is very slow but has a large sensitivity range. Fig. 2 illustrates the shape of these curves.[4]

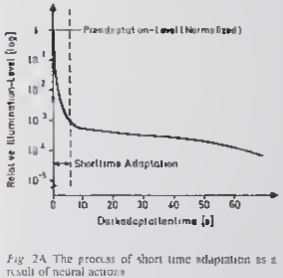

Fig. 2A. The process of short time adaptation as a result of neural action.

Visual acuity is directly proportional to light intensity for both photopic and scotopic vision although the decrease in acuity is much sharper in photopic vision. An object that can just be discriminated in a comfortable room illumination of 10 mL must be six times as large to be seen at the lower limit of photopic vision (0.01 mL) and forty five times as large to be seen at the bottom of the scoptopic range (0.00001 mL). The level of visual acuity required must therefore be assessed when determining lighting levels.

CURRENT SUBMARINE LIGHTING

There are effectively three lighting conditions in RN submarines, white lighting, red lighting and black lighting. White lighting is the normal daytime level of illumination with light levels of between 150 and 200 lux and is variable only by turning off individual light sources.

Red lighting is instituted throughout all for ward operational compartments at night time including the Wardroom and some accommodation spaces. The extent of red lighting is determined by those areas to which any potential periscope watchkeepers (which include all forward officers and command) are likely to require access in the course of their watch. The present specification for red lighting in submarines is 0.1–0.33 lux at working surfaces in the control room areas. Commanding Officers cabin and adjacent passageways with 2.2–5.4 lux at surfaces in the Wardroom heads and compartments adjacent to the control room. There is a requirement for some form of dim white lighting to be available on the chart table for colour discrimination either by pinhole torches or a very dim rheostat controlled white light. Any other displays requiring colour discrimination are covered by orange filters rather than red although the rationale for this is unknown since it does not have the advantages of red light on scotopic vision. The level of red lighting can again only be modified by turning off specific lights and by shielding other sources with masking tape.

Prior to a submarine coming to periscope depth at night the condition known as black lighting is adopted. In this case control room lighting is reduced to an absolute minimum with all background illumination extinguished and only low level instrument lighting permitted. Chart table illumination is cut down and is segregated from the periscope area by the rigging of blackout curtains. Lighting in adjoining corridors and compartments is also reduced. Officers are expected to dark adapt within the curtained area for a period of five to ten minutes before taking over a periscope watch. Should the exterior conditions be very bright for instance on a clear moonlit night the blackout curtains may be removed.

There appears to be little formal guidance to Commanding Officers on lighting levels and the

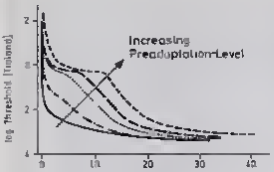

Fig. 2B The process of long time-adaptation as a result of chemical actions (parameter: preadaptation light level)

length of time required to dark adapt adequately. Most rely on experience particularly that gained on the Perisher or Commaud Qualifying Course when the adverse effect of bright white lighting on night vision is demonstrated. Furthermore, there is no standard lighting system with the lack of any form of variable control on light sources submarine crews insulate their own solutions by moving lights or masking them.

In contrast a vast amount of research and investigation on the subject of submarine lighting has taken place in the United States Navy and a clear consensus has begun to emerge.

THE RELATIVE ADVANTAGE OF RED LIGHTING OVER REDUCED WHITE LIGHTING

The advantage of red lighting over white lighting for dark adaptation is a function of the intensity of initial adaptation exposure in that as the intensity of the initial light decreases the rates of dark adaptation after red or white light become more similar. Hence red light loses its advantage over white light at low intensities. This is true when dark adaptation is measured by both the ability to detect a spot of light or to perceive fine detail although results suggest that the advantage is smaller for the light detection. Similar results have been obtained for interrupted dark adaptation and subsequent re-exposure.

Studies by Hecht and Hasta[5] and Peskin and Bjornstadt[6] using detection threshold as the criteria for dark adaptation are illustrated in Table 1. These show that at illumination levels of 1000 candela/metre^2 the difference in the time taken to dark adapt is of order of 15 minutes. However at the lower level of 10 candela/metre^2 the difference is as low as 1 to 2 minutes. Hulburt[7] measured the time to dark adapt after exposure to four different intensities of illumination and found that whereas after exposure to 100 foot candelas (1076 lux) the difference between red and white lighting was 14 minutes at 1 foot candela (10·7 lux) it was only 1 minute.

Work using scotopic acuity gives similar results and is illustrated in Table 2. Ferguson and McKellar[8] found that at levels of 0·5 foot candelas (5·4 lux) the difference between white and red lighting is as low as 15 seconds. Luria and Schwartz's work[9] showed similar results with only 1·5 minutes difference at levels of 0·19 foot lamberts.

Readaptation times after brief exposure to red and white light at low levels (0·06 foot lamberts) also show differences in the order of one minute. Of considerable practical significance more recent work by Luria and Kobus[10] showed that the ability to see simulated ship silhouettes and shadows within ten seconds of looking away from red or white light showed no significant difference in the ability to see such targets after adaptation in levels of 0·1 or 0·01 foot lamberts or when the background illumination was 0·9 or 0·06 foot candela. There is therefore no difference in the ability of periscope operators to detect silhouettes against the starlit or moonlit sky after adapting to low level red or white light. Schubert[4] carried out a similar series of experiments looking at watchkeepers on ships bridges under various lighting conditions and concluded that the human operator was able to identify objects at practical night illumination levels within seconds of being exposed to brightness levels of up to 3 lux.

These results collectively show that the difference in time taken to dark adapt after exposure to low levels of white light compared to red are very small. Some reports[4] have suggested that they are effectively negligible at exposure levels of below 3 foot candles. This view is not universal and a British review paper by Court and Wheatley[11] using work by Voss considered that red lighting could be 100 times brighter than white for the same effect on night vision. However examination of the data reveals that although this is the case at high levels of illumination it is not valid to extrapolate this to lower levels.

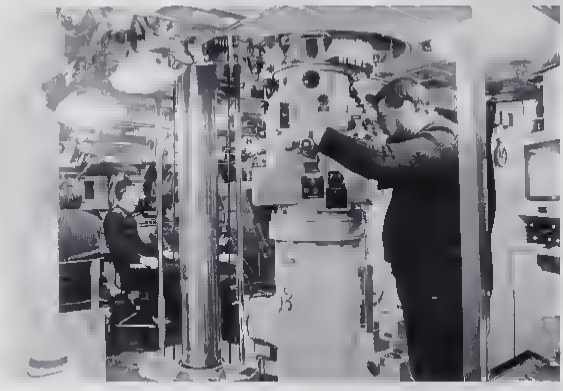

Fig 3 Control room of an SSN

Table 1 The Differences between the times taken to dark adapt between red and white lighting at varying levels of illumination (using detection threshold)

Level of Illumination Cited units	SI units	Difference in Dark Adaptation time (minutes)	Study
350 mL	1114 cd/m²	15	Hecht *et al*
30 mL	95 5cd/m²	10	Hecht *et al*
3 mL	9 5cd/m²	2	Hecht *et al*
130 mL	413 cd/m²	10	Peskin *et al*
5 mL	16 cd/m²	2	Peskin *et al*
100 ft C	1076 lux	14	Hulbert *et al*
10 ft C	107 6lux	5	Hulbert *et al*
1 ft-C	10 7lux	1	Hulbert *et al*
0 1ft C	1 1lux	1	Hulbert *et al*

PERFORMANCE AND PREFERENCE OF SUBMARINE CREWS UNDER DIFFERENT COLOURS OF ILLUMINATION

There has long been dissatisfaction with traditional red lighting in sonar control rooms in US Navy Submarines and this led one submarine crew dissatisfied with red lighting, to try broad band blue lighting on their own initiative (12) The crew felt that blue light led to a significant enhancement of their sonar performance and as a result an official test of blue lighting was carried out The favourable performance results led to a directive that all sonar control rooms be blue lighted

Table 2 The Differences between the time taken to dark adapt between red and white lighting at varying levels of illumination (using scotopic acuity)

Level of illumination Cited units	SI units	Difference in Dark Adaptation time (minutes)	Study
10 ft-C	107 6 lux	1	Ferguson et al
0 6ft C	5 33lux	0 25	Ferguson et al
22 ft-L	75 3 cd/m²	3 5	Luna et al
3 4ft L	11 6 cd/m²	3 5	Luna et al
0 2ft L	0 7 cd/m²	1 5	Luna et al

There was however no formal scientific testing of the blue lighting before it was installed and no physiological mechanism could explain the enhanced performance under blue lighting. Luria and Kobus felt there were six possible reasons for its popularity

1 Blue is the most favoured colour of adults
2 Submarine crews had brought about the changes by themselves rather than at the behest of experts and it had a novelty value
3 Group conformity may have played a part since there was surprising unanimity amongst the members of each crew as to whether they preferred blue or red.
4 Long wavelengths (red light) are known to produce actual physical discomfort and visual degradation requiring more accommodation to focus on the retina which is uncomfortable for older or far-sighted men
5 There could be some visual enhancement under blue light though a laboratory study of contrast sensitivity under different ambient colours showed no difference
6 Blue and red filters were equated for photopic levels rather than the mesopic levels at which they were actually used and thus resulted in much higher brightness for the blue light owing to the shift in the spectral sensitivity of the eye towards short (blue) wavelengths at mesopic and scotopic levels

A trial was carried out comparing blue and white lights of equal brightness and this showed that although sonar operators generally preferred blue to white light for ambient illumination white lighting was better for certain tasks It was demonstrated that detection and classification of targets was faster under white light than blue Work on operational submarines showed that crews tested at sea preferred white light As a result of these findings it was recommended that neutral density filters giving low white light, as an alternative to blue be made available to submarine sonar crews.

Further work carried out in the laboratory by Kobus and Neri[1] who measured detection times on a sonar detection task showed that the shortest detection times were found under subdued white light and no light conditions although crews still expressed a preference for blue lighting. It was therefore decided to evaluate the effects of the lighting system under operational conditions at sea and eight submarines were fitted with low level white lighting in the sonar room The results showed that after practical experience with white lighting seven out of eight crews preferred it to blue experiencing less fatigue better lighting for other tasks and a decrease in visual recognition differential The subsequent recommendation was the installation of low level white lighting in all submarine sonar control rooms[13]

In parallel with these studies consideration was being given to control room lighting It has already been shown that there is little advantage from the point of view of dark adaptation between red and white lighting at the intensities used in submarine control rooms and that red lighting has many disadvantages However before a final decision can be made to substitute white light for red its acceptability to the men who stand watch in the control room must be established Although this was demonstrated in sonar rooms the control room is a completely different working environment with different displays and the added complication of periscope operations A trial was therefore ordered and white lighting substituted for red in the control room of a nuclear submarine with questionnaires being completed by men at the end of a watch period [4] The men almost unanimously preferred low level white lighting to red However when the control room was rigged for black, the white lighting used over the chart table and the adjoining spaces appeared much brighter and more distracting than the red when seen peripherally Concern was also

expressed regarding the effect of low level white lighting on periscope vision during emergency procedures since there may not be enough time to rig the control room for black for long enough to enable the operator to completely dark adapt before coming to periscope depth. Therefore an operational evaluation of periscope use with experienced observers was planned comparing both red and low level white lighting [15].

In this study an attempt was made to solve both problems by using filters of intermediate density giving uniform lighting to control room and peripheral areas. The brightness of low level white lighting was not equated to red but made 0.4 ND dimmer. All control room watchkeepers rated the low level white lighting better than red in all performance areas. The overall quality of the white lighting was related as significantly better than the red. Less eye fatigue and fewer headaches were reported. Low level white lighting provided a significant advantage over red lighting in discriminating colour coded information and in general mobility. Furthermore the subjects found themselves much more likely to stay awake to complete other tasks after their watches. Despite overcast conditions on the surface all targets were quickly detected through the periscope under both lighting conditions and all periscope watchkeepers reported no difference between their performance under the low level white lighting and red lighting.

DISCUSSION

Specifications for white lighting in US Navy submarines lay down a recommended figure of 15 foot candela (160 lux). The specification for red lighting is 2 foot candela (21 lux). However surveys of sonar compartments and control room areas reveal intensity levels of between 0.01 and 0.6 foot lamberts in the sonar room and 0.2 to 0.33 in the control room with 0.8 foot lamberts at the chart table (14). RN submarines have a design specification of 0.1 to 0.33 lux for red lighting in the control room with 7.1 to 5 lux in the Wardroom and adjacent areas. It is clear that at this level of illumination the practical difference between red lighting and low level white lighting in terms of time taken to adapt is minimal being of the order of less than one minute. In the onboard situation this would mean that a periscope watchkeeper would have to dark adapt for an extra period of one minute in black lighting if coming from the Wardroom area but considerably less if already in the control room.

Furthermore the need for absolute dark adaptation for the periscope watchkeeper is rare. The absolute visual threshold is 3×10^{-4} lux or 0.000001 mL. Due to the presence of starlight the lowest nocturnal light level is 10^{-4} lux and on a moonlit night levels can rise to as much as 10^{-2} lux. However in view of the difficulties in contrast of objects against the sea, the dark adapted eye is going to require at least 10^{-1} lux, which is considerably higher. Considering the level of illumination on board the periscope operator is normally only required to dark adapt over a range of 3 to 4.5 orders of magnitude most of which falls within the range of the initial neural process of dark adaptation lasting only a few seconds and is colour independent. Each individuals threshold for light detection varies and tends to fall off with age.

The periscope watchkeeper is looking for two sources of information during his watch that of lights of shipping and silhouettes of ships. Although absolute threshold may be required to discriminate a very dull light ships navigation lights in general have a long range and the constants are more likely to be due to the curvature of the earth's surface causing them to dip below the horizon. This is exaggerated by the low height of the periscope and the sea state. The most important method of detection certainly against any covert targets or submarines is by discriminating silhouettes against the horizon and all the available research on scotopic acuity has shown that under the current levels of lighting used in submarine control rooms there is a negligible difference in detection following exposure to low level red or white lighting.

In view of these findings there appears to be scientifically and operationally established case for the substitution of low level white lighting for red lighting in submarine control room areas.

SUMMARY

Red lighting has been shown to be unpopular and detrimental to the performance of a wide range of control room tasks. The only justification for it in the control room of a modern submarine has been the increased speed of dark adaptation. It has been demonstrated that at the control room lighting levels currently in use the advantage of red lighting is less than one minute in the time taken to reach maximum

sensitivity and negligible if considering ship silhouettes Research in the United States Navy has demonstrated that low level white lighting enhances performance and is popular amongst submarine crews There is considered to be no justification for the continued use of red lighting as the standard night regime in Royal Navy submarines and it is strongly recommended that low level white lighting be substituted

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APPENDIX

Units

Luminous intensity describes the illuminating power in a source in a particular direction and is measured in candela (cd)

Luminous flux is the light emitted by a source or received by a surface irrespective of direction and is measured in lumen (lm) 1 candela emits an illuminous flux of 1 lumen per unit solid angle

Luminance expresses the intensity of the light emitted by unit area of a reflecting or luminous surface in a given direction and is measured in candela per square metre A perfect diffuser receiving an illumination of 1 lux has a luminance of $1/\pi$ candelas per square metre

Illumination is the process of lighting an object the incident luminous flux on a surface per unit area and is measured in lux (equals 1 lumen per square metre) 1 candela produces an illumination of 1 lux at 1 metre

Confusion may arise because of the copious use of non-SI units in American literature. 1 lambert (L) is a measure related to the unit of illumination from the concept of a perfect diffuser which when receiving unit illumination can be regarded as having unit luminance in any direction of viewing. It equates to 1 lumen per centimetre^2 emitted. A foot lambert is a unit of luminance equal to 3 42 candela per square metre It equated approximately to a millilambert The foot candle is a measure of illumination equal to 10 76 lux

1 foot candle = 3 4 mL 1 foot lambert = 1 1 mL A foot candle is a unit of light emittance (luminance) A foot lambert is a unit of reflectance. (Illumination of a perfect diffuser) When the reflecting surface emits 100% of the light falling on it 1 FT L = 1ftC

1 lambert = $10^4/\pi$ candela/metre^2 = 3183 Cd/m^2
1 foot lambert = $1/\pi$ candela/foot^2 3 42 Cd/m

J roy nav med Serv 1988 74 86–94

The Incidence of Symptomatic Urolithiasis in Royal Naval Submariners: A comparison with personnel of the surface fleet

P I Raffaelli

Abstract

Submariners are exposed to a number of environmental dietary and behavioural factors thought to be associated with urolithiasis A comparative study of the incidence rate in submariners and non submariners over a seven year period was carried out

A total of 267 cases of urolithiasis resulting in illness of 48 hours or greater duration were recorded during the years 1979 to 1985 of which 251 were available for study Thirty four were identified as submariners and 217 as non submariners (84% successfully identified) The total person years at risk for the two groups were 45 171 and 311 619 respectively The crude incidence rates indirectly standardised incidence ratio the indirectly standardised incidence rates and the relative risk were calculated Although each respective rate was greater for submariners than that for non submariners the differences were not statistically significant It is concluded that this study has failed to identify an increased relative risk for submariners to develop symptomatic urolithiasis

INTRODUCTION

There are geographical variations in the incidence of urolithiasis across Europe with the incidence rate varying from 1 07% to 3 6% in men producing calculi The incidence in women is about half that for men

Some 90% of stones contain calcium of which approximately one third are a mixture of phosphate magnesium ammonium phosphate and carbonate salts one third are calcium oxalate and the remaining third are a mixture of calcium oxalate and other salts. Just under 10% of stones are formed from uric acid and a small number are formed from cystine or xanthine Ten years ago in only 20 to 30% of stone formers could a specific cause be identified [1] Although an increasing number of risk factors have been identified in a large number of cases no specific cause is demonstrated Known risk factors include anatomical anomalies of the urogenital tract infection hyperparathyroidism sarcoidosis prolonged immobilisation myeloma or carcinomatosis renal tubular acidosis and certain inherited enzyme defects such as gout cystinuria hyperoxaluria and idiopathic hypercalciuria However in many cases no specific defect can be identified Research has involved attempts to identify factors which can either increase the urinary concentration of the stone constituents to the point of supersaturation and crystallisation or which can decrease the concentration of various inhibitors of crystallisation such as citric acid and the glycosaminoglycans These factors may be dietary environmental or behavioural

Factors associated with stone formation include a high intake of animal protein and fat refined carbohydrate and ascorbic acid and a low intake of fibre non cellulose polysaccharide magnesium phosphate vitamin A and thiamine [2,3,4] Other dietary factors associated with an increased risk include overconsumption of milk and dairy products alcohol excess tea or coffee and also a low overall fluid intake [5,6] The importance of the hardness or otherwise of the potable water however is

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nuclear [7,8] In the occupational setting cadmium has been identified as an associated factor[9] as have been the more sedentary types of employment [10]

With the introduction to the Royal Navy in the 1960 s of nuclear powered submarines there was concern that the environmental stressors of prolonged submergence could lead to an increase in morbidity in submariners However initial studies demonstrated an overall decrease in morbidity in submariners with respect to non-submariners [11 12] A further study of morbidity in the submarine service during the years 1969–1974 again showed that, in general sickness admission rates and incidence rates were significantly higher to non-submariners than in submariners but that to some disease categories including genito urinary disorders the rates were contrary to the general trend.[13]

The environment to which submariners may be exposed to for up to ninety days differs in many ways from that of those living above the water and influences both directly and indirectly a number of the factors which may be associated with urolithiasis the latter by the induction of behavioural changes rather than by alterations in the environment *per se* A recent study looking at the diet of submariners serving in diesel submarines found the daily intake of calcium fat and unrefined carbohydrate to be well above their respective UK averages.[14] The daily intake of fibre was to a lesser degree also above the UK average but there is some evidence that this is not the case in the more extended patrol situation of nuclear powered submarines where commonly the supplies of fresh fruit and vegetables begin to perish after a few weeks Tea and coffee appears to be drunk in prodigious amounts by many Although alcohol is not banned its consumption is limited while at sea indeed, an increasing number of submariners voluntarily choose to abstain completely

Other environmental factors include the potable water produced from sea water with a resulting minimal trace element content and the lack of sunlight (however the role of 25 (OH) and 1 25 $(OH)_2$ cholecalciferol in idiopathic urolithiasis is uncertain[15]) The limited space and the task itself ensures that the lifestyle is sedentary in nature

Of especial interest in submariners has been the effect of prolonged exposure to elevated levels of carbon dioxide As the submarine serves both as the submariners home as well as workplace Occupational Exposure Levels (OEL s) are not applicable OEL s have therefore been replaced with a time weighted continuous exposure limit for various atmosphere constituents or contaminants known as the Maximum Permissible Concentration (MPC). The MPC for ninety days for carbon dioxide is set at 1% (7 6 mmHg) [16] This is a level which can realistically be achieved with the atmosphere purification equipment carried onboard nuclear powered submarines

Early Animal studies demonstrated an increase in kidney calcification which was postulated to be due to chronic exposure to elevated levels of carbon dioxide [17 18] However more recent work has called into question the methodology of these earlier studies Human studies carried out by the Royal Navy at the Environmental Medicine Unit at the Institute of Naval Medicine and by the French Navy suggest that the changes noted in urinary calcium excretion in the earlier studies were due to a chamber/confinement effect[6,20] rather than as a result of exposure to the elevated carbon dioxide levels *per se*.

It is generally concluded that the progressive fall in urinary calcium excretion observed in these studies would be preventable with a well maintained exercise programme and a tight control of diet

However neither of these are undertaken on patrol The changes in renal handling of calcium return to the pre exposure levels within days of returning to a normal atmosphere

Much of this and related studies have been summarised in two reports from the United States Navy [21 22]

It should be recognised that submariners are also employed in shore based positions with no sea going duties Ideally shore based drafts alternate with sea going drafts with each lasting two to three years but there is much individual variation

Even within the sea going drafts there are periods of up to three months spent ashore Indeed it is the routine with the nuclear powered Polaris missile carrying submarines (SSBN—Ship Submersible Ballistic Nuclear) to operate with two crews in order to maximise the time the submarine is at sea the two crews alternate on a basic three monthly cycle The Royal Navy also has a number of nuclear powered non missile carrying submarines with prolonged submergence capabilities (SSN—Ship Submersible Nuclear) These operate with one crew but with an excess of personnel so that at all times a proportion are shore based

Finally there are also a number of diesel electric powered submarines which do not have the same submergence and atmosphere purification capabilities as the nuclear powered submarines (SSK—Ship Submersible Conventional) They do however share many of the environmental factors with SSBN S and SSN S that are associated with urolithiasis As they normally depend on ventilating to remove carbon dioxide a procedure which involves the submarine s mast s breaching the surface of the water and hence increasing the likelihood of detection the routine has been to allow the carbon dioxide to build up well above the levels applicable to the nuclear powered submarines before ventilating If ventilating is operationally undesirable they also carry non regenerative carbon dioxide absorption equipment which will maintain within limits the carbon dioxide level However as these units function better the higher the carbon dioxide level they are not run continuously but rather in a cyclical fashion resulting in a fluctuating carbon dioxide level with peaks above 1%

In addition to this background of factors with the potential to influence urinary stone formation it has also been clear from discussions with colleagues involved in the medical care of submariners that many have formed a subjective assessment that the incidence rate of urolithiasis in submariners is greater than the incidence rate in non submariners It is of interest to note that the United States Navy embarked upon a study to ascertain the effect of the administration of magnesium oxide on renal calcium excretion in submariners during a patrol predominantly because of a similarly subjective conclusion that the submarine environment might predispose the crew to a higher incidence of urinary tract stone formation [2]

In order to ascertain whether the combined effect of these factors has been to increase the incidence rate of urolithiasis in Royal Naval submariners in comparison with the rate in non submariners a retrospective study of the incidence rates in the two populations has been undertaken

METHODS

The study population comprised Royal Naval submariners serving during the years 1979 to 1985 Submariners are mainly drawn from the surface fleet and once qualified tend to remain within the submarine service Comparison was made with male RN personnel of the surface fleet

Each F Med 14 received at the Ministry of Defence Medical Statistics Department at Simmore is coded by a nosologist in accordance with the International Classification of Diseases[3] prior to incorporating the record on to the system Other details recorded include an abbreviated service number name coded rank category age at presentation ship class from which admitted initial date of illness or admission and the discharge date

Three hundred and eighty eight cases were of calculi within the urinary tract and cases accessed by ICD codes in order to identify cases of renal colic Of the cases identified, 121 were for second or third admissions It had been intended to categorise the remaining 267 cases into submariners and non submariners by using the recorded ship class but an examination of a sample of Fs Med 14 extracted from microfilm demonstrated that this would prove to be inaccurate as the ship recorded on the retinal F Med 14 is frequently that of the Sick Bay responsible for the man s treatment rather than the ship on which he was serving at the time of presentation

However the computer division at HMS *Centurion* were able to accurately identify 251 personnel (94%) out of the 267 cases of submariners or non-submariners by matching the date of presentation for each man with his service record The identification process was the same for submariners and non submariners and it is considered that no bias was present in those cases in which categorisation was not possible

HMS *Centurion* was also able to provide the respective strengths in March of each year as recorded for manpower and pay purposes, for each of the seven years These numbers were then further divided by age

RESULTS

Two hundred and fifty one cases of urolithiasis presenting during the period were available for study Of these 34 were submariners and 217 were non submariners The crude incidence rates were 75 27 per 10^5 person years and 69 64 per 10^5 person years respectively (*Table I*) The relative risk was 1 08 the 90% confidence interval being 0 80 to 1 46 The increase in the relative risk is not statistically significant at the 90% level ($p>0.1$)

Table 1 Submariner and non submariner crude incidence rates

	Cases	Population at Risk	Incidence Rate 10^5 person years
Submariners	34	45 171	75 27
Non submariners	217	311 619	69 67

Relative Risk = 1 08 90% confidence interval = 0 80 to 1 46 $p > 0$ 1

Table 2 Submarine Flotilla
Number of Personnel in each age group

Year	Under 20	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55 And Over	Total
1979	444	2306	1116	1297	668	184	31	5	Nil	6051
1980	326	2476	1246	1264	787	179	27	2	1	6308
1981	459	2378	1390	1155	844	155	12	2	1	8395
1982	483	2216	1646	1039	975	163	17	2	Nil	8541
1983	290	2104	1662	960	1075	196	32	4	Nil	8545
1984	167	1894	2142	965	1112	326	62	10	Nil	8989
1985	194	1827	2246	1042	1109	358	54	12	Nil	8942
Total	2362	15001	11668	7723	6570	1563	225	37	2	45171

Mean Age 27 8 years
Standard Deviation 6 41
Mode 20–24 years
Median 25–29 years

Table 3 Surface Fleet
Number of Personnel in each age group

Year	Under 20	20–24	25–29	30–34	35–39	40–44	45–49	And 50–54	55 Over	Total
1979	8505	10264	7017	6965	4605	1611	372	86	24	45358
1980	8440	15872	6422	6312	4758	1651	452	106	31	44144
1981	8664	16126	6854	5747	5244	1765	530	144	36	46102
1982	7568	16310	7533	5197	5576	1861	556	181	43	44925
1983	6260	16775	8841	4730	5662	1844	571	217	46	44076
1984	4244	16965	10025	4684	5526	1845	545	244	49	43827
1985	4393	14853	10679	4620	5374	1847	513	252	81	43032
Total	48064	112967	57671	38358	36778	12724	3539	1230	290	311619

Mean Age 26 6 years
Standard Deviation 7 30
Mode 20–24 years
Median 20–24 years

The age structures of the two populations are also different the mean age of submariners being 27 8 years with a standard deviation of 6 41 The mean age of non-submariners was 26 6 years with a standard deviation of 7 30 (*Tables 2* and *3 Figs* 1 and 2)

Indirect standardisation using the non-submariners as the standard population further reduces the difference in the symptomatic urolithiasis incidence rates of the two populations giving a standardised incidence ratio of 1 033 and a standardised incidence rate for submario-

Table 4

	SURFACE FLEET			SUBMARINE FLOTILLA		
Age	Person Years At Risk	Cases	Incidence Rate 10^5 Person Years	Person Years At Risk	Expected Cases	Observed Cases
Under 20	48 064	6	12 48	2 382	0 30	2
20–24	112 967	43	38 06	15 001	5 71	4
25–29	57 671	31	53 75	11 668	6 27	7
30 34	38 359	48	125 13	7 753	9 66	7
35 39	36 775	43	116 93	6 570	7 33	7
40–44	12 724	19	149 32	1 563	2 33	7
45–49	3 539	16	452 11	225	1 02	Nil
50–54	1 230	9	731 71	37	0 27	Nil
55 end over	290	2	689 66	2	0 01	Nil
Total	311 619	217	69 64	45 171	32 81	34

Standard sed Incidence Ratio = 34 − 32 91 = 1 033
Standard-sed Incidence Rate = 1 033*69 64 per 10^5 person years
= 71 94 per 10^5 person years
Standard ErrorSIR = SIR − Vr (approx) where r = observed cases
$SE_{SIR} + 1\ 033 - 5\ 83 = 0\ 18$
90% confidence interval = 0 71 to 1 29 $p > 0\ 1$
The difference in the two rates is not statistically significant

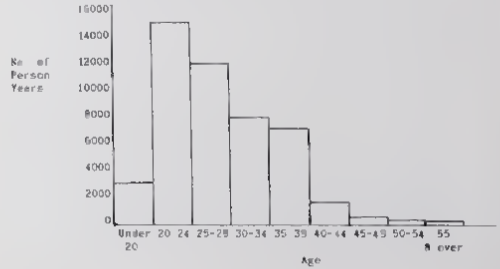

Fig 1 Submarine Flotilla 1979 to 1985 Total Person Years by Age

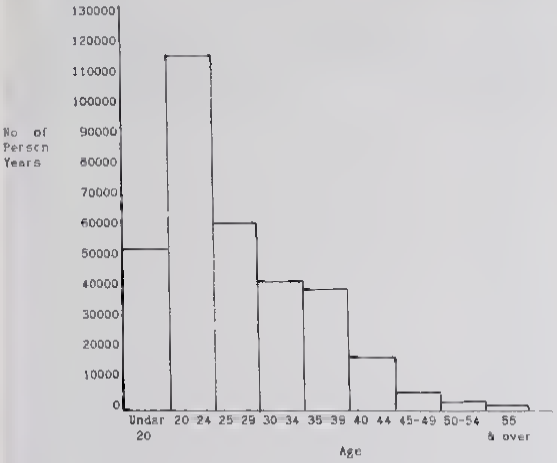

Fig 2 Surface Fleet 1979 to 1985 Total Person Years by Age

ers of 71 94 per 10^5 person years at risk. This is not statistically greater than the rate for non-submariners (*Table 4*)

The number of cases of symptomatic urolithiasis occurring in the two populations during each year of the period under study shows only minor variation between years within the populations (*Fig* 3) This degree of consistency in the data is encouraging but does not necessarily imply validity as it may simply represent a consistent bias in the identification or recording of cases in one or other of the categories This is considered to be unlikely (*qv*)

DISCUSSION

Submariners are drawn from the surface fleet often at an early stage of their career Although all members of the Royal Navy are subject to medical selection and regular periodic medical review and are held to be generally fit those who volunteer or are selected for service in submarines undergo a further specific medical examination prior to submarine training Personnel identified at this stage as having a history of frank urolithiasis would be referred to the Royal Naval consultant in urology for consideration of the man s fitness to join the submarine service [25 26]

Submarine training is extensive expensive and time consuming If therefore a trained submariner develops an illness at a later stage as might be likely with urolithiasis, every effort is made to retain the man in the submarine service This would include a substantial period of time during which the man would not be

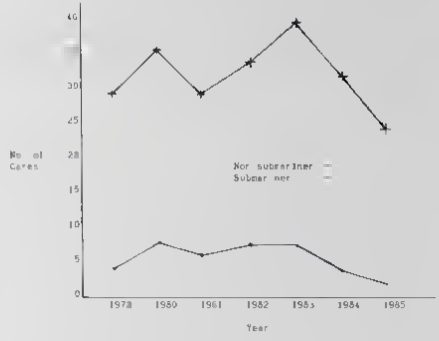

Fig 3 Cases of Symtomatic Urolithiasis 1979–1985 Submarines and Non submariners

allowed to go to sea He would undergo full renal work up shortly after presentation and at a later date after receiving counselling on diet and fluid intake Those who remain symptom free and have a normal intra venous pyelogram and urinary excretion studies are likely to be reinstated to full submariner duties by the Royal Naval consultant in urology albeit with further reviews in the future However a number will not improve and will be made permanently unfit for service in submarines At this point the man may either return to the surface fleet or may leave the service entirely If a man had left the submarine service in these circumstances prior to 1979 and then had a further episode of urolithiasis as is probable then he would not have been identified as having initially presented as a submariner

The actual relevance of this with respect to causality is not absolutely certain as on one hand the environmental factors in the submarine service which are considered to be associated with urolithiasis would not have been experienced by the man for a considerable period of time but conceivably could have created a nidus for subsequent calculus formation

It is clear nonetheless that the medical selection of submariners and the medical deselection of resistant cases of urolithiasis from the submarine service might lead to a "healthy worker effect and thus may potentially result in an underestimation of the incidence rate in submariners However the numbers involved and hence the size of the effect are likely to be low The effect is further mitigated as it is incidence rates and not prevalence rates which are being compared

Only cases of 48 hours duration or longer are recorded on FS Med 14 but it is probable that any personnel suspected of having suffered acute renal colic and having passed a calculus spontaneously within the 48 hour period would be referred for further assessment this would certainly be undertaken if the man was a submariner It is probable that a stone former would enter the record system at this stage Although it is possible that this might have resulted in slight increase in the reporting rate in submariners it is considered that any such effect would be minimal

A possible source of bias is the treatment of the submariner population as a homogenous entity with respect to their exposure to the

factors associated with urolithiasis As stated there are considerable differences in exposure depending on whether the man has a shore based draft or a sea going draft and with respect to the latter to which type of submarine. However it is unclear whether there is a lag period between exposure and developing clinically detectable urolithiasis. Cases of submariners actually presenting with a renal calculus while at sea are rare As the presentation of a calculus could thus occur at some undefined time after the submarine has returned from sea during which time the man may have been drafted it was not practicable to further categorise the submariner population into sea going and shore based sub groups. The degree to which this might serve to reduce the incidence rate in submariners is uncertain but is unlikely to be significant.

The lack of any evidence particularly when the rates are corrected for age to support the hypothesis that submariners have an increased incidence rate of symptomatic urolithiasis in comparison with non submariners is encouraging. It is important however to continue to seek to reduce the environmental factors to which people are exposed where practicable A diet containing more fibre and less refined carbohydrate and fat is to be encouraged for many reasons Work is also being undertaken at present to assess the practicalities of replacing the standard fluorescent lights on submarines with a full spectrum fluorescent light which closely mimics sunlight (and hence encourages vitamin D synthesis) If introduced both of these changes will make any association between the submariner s environment and his developing urolithiasis even less likely

CONCLUSION

This study shows no increased relative risk for submariners serving in the Royal Navy during the years 1979 to 1985 to develop symtomatic urolithiasis when compared to the members of the surface fleet during the same period

ACKNOWLEDGEMENTS

I am indebted to Mr C Lewis Head of Medical Statistics, Ministry of Defence Stanmore and Mr A P Arrowsmith Computer Division HMS *Centurion*, Gosport for their invaluable assistance in collating the data

I am grateful to Surgeon Commander G H G McMillan Professor of Naval Occupational Medicine and Dr R Pellybridge Institute of Naval Medicine Alverstoke for their advice and encouragement and also to Dr H A Waldron London School of Hygiene and Tropical Medicine for his constructive criticism

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J roy nav med Serv 1988 74 95–99

Coxsackie B Viruses and the Post Viral Syndrome in Nuclear Submariners

P J Warnock, E J Bell and M H Riding

Summary

Sera from 168 submariners the entire crew of a Polaris submarine were tested for Coxsackie B Virus (CBV) specific IgM antibodies using a μ antibody capture enzyme linked immunosorbent assay (ELISA) 36 (21%) were positive or weak positive with 22 (13%) confirmed by CBV neutralisation tests (NT) suggesting recent or active CBV infection The sailors were observed over a two year period during which three patients (2%) developed illnesses suggestive of the post viral fatigue syndrome These cases all previously seronegative for CBV did not seroconvert once they became unwell and their illnesses are presumed to have been due to other viruses The prevalence of CBV infections and the post viral fatigue syndrome in this close and confined community are discussed

Introduction

THE post viral (fatigue) syndrome has attracted increasing interest in recent years. This enigmatic condition also known as myalgic encephalomyelitis (ME) neuromyasthenia Royal Free Disease and Iceland Disease has been viewed by some as mass hysteria and is the subject of continuing controversy The topic was reviewed by Behan[1] and a 1978 symposium at the Royal Society of Medicine[2] found the evidence in favour of an organic basis compelling A recent symposium reported by Dawson[4] highlighted the persisting difficulties of definitions and diagnosis but emphasised the probable viral aetiology of this syndrome

Coxsackie B viruses (CBV) RNA viruses of the enterovirus group are known to be associated with Bornholm Disease aseptic meningitis and myo/pericarditis and have been linked with the post viral syndrome in a series of general practice-based studies in the West of Scotland[5,6]

Fegan *et al*[5] described an epidemic while Keighley and Bell[6] reported a more endemic pattern in a rural practice Calder and Warnock[7] found antibodies to CBV in a significant proportion (38 of 81 tested—47%) of a group of patients afflicted by a curious range of symptoms In a prospective study Calder *et al*[8] demonstrated a continuing association between this illness and positive CBV serology 46% of 140 patients were positive compared with 25% of 100 controls

These studies were based on neutralisation tests (NT) using a micrometabolic inhibition test[9] which detects CBV specific IgG Although epidemiologically useful interpretation of static high neutralisation titres has been difficult in individual cases because neutralising antibody may persist at high titre for long periods following infection Recently the introduction of a μ antibody capture CBV specific IgM enzyme linked immunosorbent assay (ELISA)[10] into routine use at the Enterovirus Reference Laboratory Ruchill Hospital has provided in combination with NT a more confident serological indicator of recent or continuing CBV infection

Behan *et al*[11] studied 50 cases of ME and

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described a metabolic disorder caused by persistant viral infection associated with defective immunoregulation as the probable cause Immunological abnormalities have similarly been described in chronic illness following infections mononucleosis [12] In the crowded environment of submarines acute viral infections are extremely common. Early in 1985 when blood was obtained from every member of the ship's company of a Polaris submarine (because of a Hepatitis A immunity screening programme) a valuable opportunity was afforded to study the prevalence of CBV infections in nuclear submariners

METHODS

Patients

168 nuclear submariners had blood taken during a two day period in February 1985 The age range of this all-male population was 18–43 years (mean 30 5 years) but the vast majority (87%) were 19–33 years The separated sera were frozen for subsequent CBV antibody testing The patients were observed over a two year period retrospectively for six months (aided by the daily sick book and personal medical documents) and prospectively for 18 months (on the basis of spontaneous clinical presentation) with a view to identifying any cases of the post viral syndrome During this period the crew remained under the care of one of the authors (PJW) and they were not aware that this scrutiny was proceeding

Serology

All sera were tested for CBV (serotypes 1–5) specific IgM using the μ antibody capture ELISA [8] Positive and weak positive sera were tested for CBV neutralising antibody (IgG) as a means of confirming the significance of CBV specific IgM Positive IgM without IgG implies cross reaction caused by another enterovirus All IgM positive sera were also tested for Hepatitis A specific IgM which is known to cause false positive CBV IgM results As in previous studies[5 8] NT titres $\geq$512 were regarded as indicative of and titres of 256 as suggestive of recent infection

RESULTS

Serology

Of the 168 sera tested, 36 (21%) were positive or weakly positive for CBV specific IgM (*Table 1*) of these 36 positive sera 22 (61%) were associated with significant titres of CBV neutralising antibody (*Table 2*) The positive and weak positive cases were equally likely to have positive NTs None of the 36 positive sera was found to contain Hepatitis A specific IgM

Of the 22 IgM positive cases confirmed by NT there was serotypic matching IgM/IgG in 14 (64%) 26 (76%) of the 36 sera had monotypic IgM response whereas only 9 of the 22 (41%) positive NTs showed a single serotype response This reflects the anamnestic response commonly found with neutralising antibody As in previous studies antibodies to CBV serotypes B2 and B4 were commoner than B1 B3 and B5

Patients

At the time of the blood tests none of the subjects was suffering from any condition resembling the post viral syndrome A retrospective analysis did not suggest any cases during the preceding six months Because of gross individual variation in the threshold for consultation it was not possible to compare positive CBV serology with short-lived acute viral illnesses. The results of the serology were not available until after the close of the study and thus it was impracticable to retest the positive cases to assess the disappearance of antibody

During the first year of the 18 month period of prospective follow up three patients (2%) developed illnesses suggestive of the post viral syndrome and these are described. All three cases were negative for CBV IgM at initial testing

Case One

A 29 year old officer suffered an acute febrile illness with malaise, sweating, headache nausea and loose stools Following resolution of the acute phase a more protracted illness developed characterised by tiredness poor concentration back pain, sweating nausea and continuing loose stools His wife became unwell with similar symptoms. Initial physical examination and laboratory investigations were negative except that the patient looked ill and there was a modest elevation of serum transaminases Hepatitis A and B serology were negative as were the monospot test and a full viral screen A post viral syndrome was suspected but CBV IgM was negative both in the patient and his wife

The patient was admitted to a teaching hospital where exhaustive investigations were carried out but no definitive conclusion was

Table 1 36 CBV IgM positive sera correlated against NT

Patient	CBV IgM positive	CBV IgM weakly positive	CBV Neutralising antibody titre					CBV IgM positive confirmed by NT
			B1	B2	B3	B4	B5	
1	B4		*256*	*512*	128	*1024*	64	+
2	B3		<64	<64	128	<64	<64	–
3	B3		<64	<64	128	<64	<64	–
4	B2 B4		<64	128	<64	> *1024*	<64	+
5		B2	*512*	*512*	64	> *1024*	*256*	+
6	B4		<64	<64	<64	<64	<64	–
7	B3		128	<64	<64	<64	<64	–
8	B3		<64	<64	<64	<64	<64	–
9	B3		128	<64	<64	<64	> *1024*	+
10		B2	<64	<64	<64	*512*	<64	+
11		B3	<64	*256*	<64	*256*	<64	+
12	B5		<64	<64	<64	<64	<64	–
13		B2	*512*	<64	<64	<64	<64	+
14	B4		64	<64	<64	> *1024*	<64	+
15		B2	64	<64	<64	128	64	–
16		B2	*256*	64	<64	*512*	<64	+
17		B4	<64	<64	64	*512*	<64	+
18		B2	*512*	*256*	<64	<64	64	+
19		B4	<64	<64	*256*	*512*	<64	+
20		B1 B2 B4	*512*	> *1024*	*512*	<64	64	+
21	B2 B4		<64	*512*	<64	> *1024*	<64	+
22	B2 B3 B4		<64	<64	64	*512*	<64	+
23		B2	<64	64	<64	*256*	<64	+
24	B3		<64	<64	<64	<64	<64	–
25	B3		<64	*256*	64	<64	<64	+
26	B1 B5		<64	128	<64	<64	<64	–
27		B5	<64	<64	64	<64	<64	–
28		B2	<64	<64	<64	*1024*	<64	+
29	B2 B4 B5		128	64	<64	*256*	<64	+
30		B2 B5	<64	128	64	128	<64	–
31	B4		<64	128	64	64	<64	–
32		B5	<64	<64	<64	128	64	–
33	B2		<64	*512*	128	> *1024*	64	+
34		B4 B5	<64	64	128	*1024*	<64	+
35		B4	<64	<64	<64	*512*	<64	+
36	B2		<64	128	<64	<64	<64	–
TOTAL	18	17						22

NOTE significant NT titres are in italics

reached A tentative diagnosis of post viral syndrome was made The patient and his wife slowly recovered but it was six months before he was fit enough to perform his normal work and a year before he felt consistently well

Case Two

About a month after the onset of case one a 20 year old stoker suffered an acute febrile illness which again led on to a more chronic condition The features were broadly similar to case one though less severe All investigations (including transaminases) were normal and the monospot test Hepatitis A and B serology and CBV IgM ELISA were all negative Nonetheless malaise nausea, sweating and anorexia persisted with

Table 2 Relationship between positive/weak positive CBV IgM and neutralising antibody titre

neutralising titre	Number of patients		
	IgM positive	IgM weak positive	Both IgM and NT positive (%)
≥1024	6	4	10 (6%)
512	1	7	8 (5%)
256	2	2	4 (2%)
		TOTAL	22 (13%)

Table 3 Comparison of CBV results in submariners and well adults (Lanarkshire) both sampled in February 1985

Patients	Number CBV IgM positive (%)	Number CBV IgM positive confirmed by NT
186 submariners	36 (21%)	22 (13%)
92 well adults (Lanarkshire)	8 (9%)	4 (4%)

gradual improvement over several months The patient was considered fit for normal work at three months but did not feel completely recovered until six months had passed

Case Three

Six months after the onset of cases 1 and 2 a 25 year old Petty Officer developed a three day febrile illness with sore throat A few days after this he started to suffer episodes of dizziness and lightheadedness which heralded the onset of a protracted illness the main features of which were malaise poor concentration palpitations chest pain truncular twitching and fitting paraesthesia

Investigations revealed a mild derangement of liver function tests but hepatitis serology and CBV IgM tests were negative The patient was seen by a consultant physician who felt that this was a clear cut case of the post viral syndrome There was a fairly rapid improvement over a few weeks but a relapsing course was seen the intervals between episodes gradually increasing. The patient was off work for a month and did not feel generally well for six months A year after the onset he still experiences minor attacks of paraesthesia and palpitations

DISCUSSION

The finding of serological evidence of recent or active CBV infection in 22 (13%) of 168 submariners demonstrates that these infections were relatively common in this population at least at the time of the study These figures can be compared (*Table 3*) with unpublished data from 92 healthy adults (44 male 48 female—age range 17 to 60 years) from an adjacent area (Lanarkshire) fortuitously tested for CBV during the same month as part of a population screening programme It should be noted that there is a seasonal variation in enterovirus activity which is maximal in the autumn [13] The figure of four per cent CBV positive in the Lanarkshire adults is similar to the results of a larger study[14] where 1 000 healthy West of Scotland adults were tested by NT alone between 1973 and 1984 4–5% had NT titres of 512 or above and 10–12% had titres of 256 [10]

The significance of CBV infection in individual patients with suspected post viral syndrome remains difficult to assess Previous studies[5 8 10 11] found a significant proportion of cases to have elevated CBV titres but other clinically indistinguishable cases were negative On the other hand as in the present study many people with serological evidence of CBV infection remain perfectly well

The discovery of three cases (2%) of post viral syndrome in such a small population is rather surprising. All three cases were initially nega

tive for CBV IgM and remained so after they became unwell It is suggested that these illnesses were due to other viruses It is not clear if the finding of these cases reflects a high incidence in this group or the common failure to diagnose the condition

There is a need both for increased awareness amongst physicians of this distressing complaint and for more research to establish reliable diagnostic criteria.

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J roy nav med Serv 1988 74 100–106

Physiological Problems in the Use of Submarine Escape Chambers

D G Jones

INTRODUCTION

In 1885 an American professor named Josiah L. Tuck designed and built a submarine called the *Peacemaker* (*Fig. 1*). The boat was tested in the Hudson River and developed a severe leak around the hatch. At this point, not surprisingly perhaps, one of the crew became hysterical and Tuck had to pacify the gentleman with a hammer. The crew escaped successfully by allowing the water to come in until the pressure inside the submarine equalled that outside then pushing open the hatch and swimming to the surface.[1]

Although Tuck may have ushered in a new era in relations between a submarine commander and his crew during the conduct of a submarine escape he was not the first to escape successfully from a disabled submarine. This distinction belongs to Wilhelm Bauer a Bavarian Army Corporal who had built a submarine called the *Brandtaucher*. In 1851 during operations off Kiel the *Brandtaucher* settled on the bottom in sixty feet of water and refused to ascend despite the efforts of its three man crew. Bauer without any apparent objection from his crew instituted the pumping in of water until the pressures inside and outside the boat equalised and they were then able to escape.

These episodes illustrate the basic principle of submarine escapes which is the need to raise the pressure within the submarine to that of the water outside.[2] This raised pressure can lead to immediate problems due to the increased partial pressure of atmospheric gases e.g. oxygen toxicity, nitrogen narcosis or carbon dioxide poisoning, and problems after the escape with decompression sickness or arterial gas embolism. It can readily be appreciated that in order to reduce the incidence and severity of these problems time spent under pressure must be minimised.

Surgeon Commander Jones is Principal Medical Officer HM Naval Base Rosyth

HISTORICAL ASPECTS

The first British submarine accident was in March 1904 when the *A 1* was sunk off Spithead after being struck whilst submerged by a Union Castle liner.[3] These early submarines were comparatively small consisting of a single compartment with no watertight bulkheads. Any uncontrolled ingress of water led inevitably to complete flooding and the subsequent salvage of the submarine as quite often occurred, was no consolation to the crew who had all drowned. The *E* class submarines were fitted with bulkheads to form watertight compartments and it was hoped that this would enable the crew to isolate the flooded compartment and survive in the unflooded portion of the boat until rescued by salvage methods.

The first real escape from a Royal Navy submarine occurred in 1916 when a member of the crew of HM Submarine *E 41* was trapped in a compartment 30 feet below the surface. He escaped by flooding the compartment until the pressures equalised then after several unsuccessful attempts, managing to lift a hatch open and float to the surface. In a subsequent accident shortly afterwards the fore-end of *K 13* was raised to the surface to effect the rescue of the majority of the crew and three crewmen who had attempted individual escape

from the after compartments drowned The comparative success of salvage on this occasion meant that it became the primary method of rescuing survivors However *X 13* was the ideal candidate for successful salvage The submarine was at a depth of 38 feet in the Gareloch and easily accessible to divers and there were salvage vessels close at hand

Several disasters in the six years following World War I led to a revival in the concept of individual escape The Hall Rees escape apparatus which had been issued to submarines in 1914 and withdrawn two years later was cumbersome complicated and dangerous, and only one was issued to each submarine which may have led to interesting debates as to who was going to use it should the need arise Advances in the design of diving equipment meant that improved forms of escape apparatus could be produced and following a series of trials in 1929 the Davis Submarine Escape Apparatus was adopted for use and issued to all submarines on a scale of one per man plus 20 per cent additional sets [4]

Two subsequent accidents confirmed this policy In 1931 the *Poseidon* sank in 20 fathoms after a surface collision and although half the crew escaped up the conning tower prior to sinking and most of the remainder drowned eight men were trapped in the fore-end of the submarine Two of these men died whilst the compartment was being flooded however the other six escaped using the Davis apparatus One of the six died it is believed from arterial gas embolism having been knocked unconscious by the submarine casing when he was carried rapidly out of the escape hatch by the escaping air bubble The other five survived and this successful use of the Davis apparatus led to the institution of more thorough training and an increase in the scale of sets carried on each submarine It is also worthy of note that the problem with flooding a whole compartment i e exposing the escapees to increased pressure for a significant length of time and the subsequent difficulty in controlling egress led to the development of special escape trunks initially followed by dedicated escape compartments or towers

The *M2* sank in 1932 it is believed due to flooding through the seaplane hanger door and despite repeated attempts at salvage could not be raised In the years since then all efforts have been concentrated on individual escape although the recent advent of the US Navy Deep Submergence Rescue Vehicle has added a new dimension to the level of outside assistance which can be offered should the circumstances be appropriate

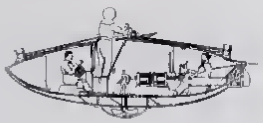

Fig 1 The *Peacemaker*

After the Second World War an Admiralty committee was tasked with analysing submarine escape experience and reviewing current escape practice [5] The principal finding was that the majority of those escaping successfully had not worn breathing sets but had merely held their breath during the tower flooding phase and exhaled on their way to the surface as the air in their lungs expanded This led to the concept of free ascent with buoyancy although the need for a source of air independent of the submarine atmosphere remained apparent The Davis apparatus continued to be used for this latter purpose until 1959 when all Royal Navy submarines were fitted with Built in Breathing Systems (BIBS)

CURRENT PRACTICE

Current escape practice in the Royal Navy involves escapees wearing Submarine Escape Immersion Suits (SEIS) which have a built in stole acting as a breathing hood and providing buoyancy in addition to the suit itself which is inflatable to provide thermal protection once the escapee arrives at the surface (*Fig 2*) The stole and the hood are inflated with air whilst the escapee is within the escape tower of the submarine by a hood inflation system (HIS) This should keep the hood pressure slightly above that of the tower during flooding of the tower prior to pressure equilibration to prevent hood collapse

It is clearly of interest to establish safe depth limits for this form of escape Since 1945 many trials have been performed using goats in compression chambers following up with Royal Naval personnel in simulated (chamber) escapes and real submarine escapes Donald[6,7] has provided comprehensive reviews of much of this work The major limiting factor at

present appears to be decompression sickness due to the nitrogen absorbed during the total time under pressure. To calculate a risk estimate for decompression sickness it is necessary to know the actual depth from which the escape occurs and an estimate for the equivalent time spent at this depth. The pressure profile during simulated or real submarine escape is shown in Fig. 3. The escape is divided into three phases.

Time of compression, time on bottom (at maximal pressure) and time of decompression (during ascent).

Donald proposed that these times could be used to calculate an equivalent depth time (EDT) in the following equation:

EDT = Compression time/2 + time on bottom + decompression time/2

This was used for linear compressions (see later) however if the compression is geometric in nature then Compression time/3 should be used. This equation assumes that absorption of nitrogen by body tissues commences immediately the pressure starts to increase, continues for the whole of the time under pressure and occurs at a rate proportional to the ambient pressure above atmospheric. In real terms this is not the case because as nitrogen builds up absorption is reduced however due to the rapidity of the whole process in modern escapes the approximation is acceptable for the purposes of calculating safe limits for escape.

The multiple of maximal depth and equivalent time at depth expressed in Atmospheres seconds is called the Depth Time Multiple (DTM) and using the results of the various trials Donald postulated that this figure can be used to predict the risk of decompression sickness.

It is difficult to believe that such a simple calculation can truly reflect the complex processes involved in the uptake and release of nitrogen by different body tissues during the rapid and dramatic pressure changes involved in submarine escape. However current experimental experience in men and goats has yet to provide a better estimate of the risk of decompression sickness in submarine escapees.

Compression Phase

In the early dry experiments compression of the escape compartment was carried out in a linear fashion either with a constant rate of increase in pressure giving a compression time dependent on depth or by using a greater rate of increase of pressure for the deeper trials such that a constant compression time was achieved. The use of depth time recorders in trial escapes from submarines showed that a more realistic compression profile could be represented by a geometric curve with the pressure doubling in constant time (*Fig. 4*). This has an added advantage over linear compression in that it reduces the time spent at higher pressures (hence the use of compression time/3 in the calculation of Equivalent Depth Time).

There have been continual efforts to reduce the compression time such that the current commonly quoted maximum compression rate is doubling the pressure approximately every 4 seconds[8]. It would appear that there are no reasons why this particular figure should have been arrived at other than a generally held belief that faster compression rates would be difficult to achieve and perhaps harmful to the escapee. In deeper escapes where time at depth is at a premium it would be useful to reduce the compression time even further. However there are certain physiological and mechanical constraints which need to be considered.

Physiological constaints comprise those due to the need for pressure equilibration between the atmosphere and gas filled spaces in the body such as the lungs and the middle ear and those due to the effects of inert gas narcosis in this case nitrogen.

It is apparent from recent trials[9,10] that using the present rapid rates of compression escapees are having some difficulty clearing their ears quickly enough indeed there were several cases with aural barotrauma involving perforation of the eardrums. It is interesting to observe from raw data from the most recent trial that the pressurisation profile departed from the theoretical doubling in constant time profile. In fact each successive doubling of pressure tended to take less time (*Table I*). This means that with the exception of one possibly freak doubling time (2.9 secs!) the shortest doubling times recorded the only two under 4 seconds were for the compression phase between 70 and 150 metres. It is also worthy of note that 6 of the 7 cases with ruptured eardrums occurred during the 17 escapes with at least one doubling time of 5 seconds or less. The only other ruptured eardrum occurred during an escape with a minimum doubling time of 5.4 seconds. The escape containing the doubling time of 2.9 seconds resulted in bilateral ruptured eardrums and of the two escapes with at least one

Fig. 2 Escapee emerging from a submarine escape chamber

doubling time under 4 seconds one resulted in a ruptured eardrum

It seems that unless it is considered acceptable to routinely burst the eardrums of exercise escapees the limit has been reached with theoretical doubling times of about 4 seconds. Of course in a real escape mural barotrauma is of little significance and its possible occurrence should not be allowed to compromise what is a life-saving procedure.

Lung squeeze during the compression phase is a possibility if air does not enter the lungs at a sufficient rate to compensate for the reduction in volume which would otherwise occur and the total lung volume is reduced to the residual volume at which point any subsequent compression results in lung damage (pulmonary compression barotrauma) If the escapee keeps his airway open lung squeeze should not occur However should he be preoccupied with clearing his ears or perhaps swallowing, (which in itself is dangerous if air is swallowed at depth), the airway may be closed for sufficient time for

Table 1 Time for Doubling of Pressure

Pressure (Atmos)	Depth (Metres)	Time (Secs)	
		(A)	(B)
1	0	0	0
2	10	9 0	11 1
4	30	6 0	6 4
8	70	4 4	4 1
16	150	3 4	3 1

Note
A and B are the pressure profiles for the two deepest escapes
(From Whiteside H C *Deep Escapex 1967 Raw data and depth/time profiles* Office of Flag Officer Submarines 1967)

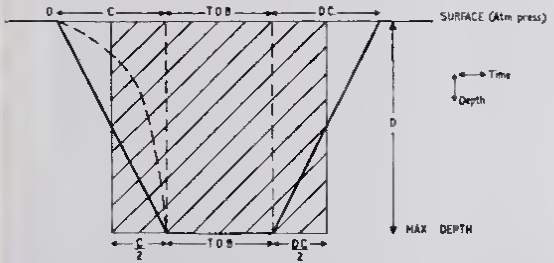

Fig 3 Diagrammatic representation of time-pressure relationships during simulated or real submarine escape (heavy line) C = time of compression T O B = time on bottom D C = time of decompression The interrupted line shows the relationship with doubling of pressure in constant time.
(From Donald K W A review of submarine escape trials from 1945 to 1970 with particular emphasis on decompression sickness. *Underwater Physiology Subcommittee Report* UPS 290 1970)

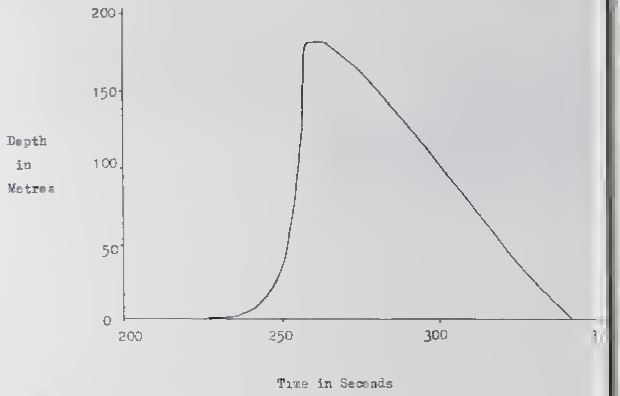

Fig 4 Pressure profile of an escape from the most recent trial
(From Whitesitt, R. C. *Deep Escapes 1987 Raw data and depth/time profiles.* Office of Flag Officer Submarines 1987)

the rapidly increasing external pressure to cause lung squeeze. It is difficult to identify a pressure doubling time at which lung squeeze might be a potential problem although it is reasonable to note that in the recent trial the three escapees with the minimum doubling times of 29, 31 and 34 seconds had no lung problems despite the fact that they were all struggling to clear their ears at a sufficient rate.

Nitrogen narcosis is not usually a problem in escape trials as the time spent under pressure is not sufficient for the onset of symptoms to occur. Escapees occasionally report lightheadedness on surfacing which may or may not be due to nitrogen narcosis and it is possible that some temporary minor intellectual impairment may occur which would rapidly resolve. It has been said that nitrogen narcosis is more pronounced with rapid compression although again the short time spent under pressure should prevent it being of any significance during the escape.

Mechanical constraints are present in two facets of the compression. Firstly the mechanism whereby water is allowed into the escape tower for pressurisation. As stated earlier it seems at present that the doubling time shortens for each successive doubling of the pressure. During the first phase there is some slight delay as the valve is opened. Although it is presumably possible to design a system that allows a faster more even compression the second mechanical constraint then becomes extremely relevant.

The hood of the SEIS as stated earlier is inflated by air from storage bottles and is theoretically kept inflated by a slight overpressure above the tower pressure. In the case of even more rapid compression it is crucial that this system could cope. In the most recent trial several escapees had problems with the hoods collapsing or partially filling with water both frightening and dangerous. Any malfunction in this system is bound to cause some degree of panic in the escapee and compromise his ability to successfully clear his ears and negotiate the

rest of the escape safely It was concluded that more work is needed on the Hood Inflation System to improve its performance particularly if faster compression times were to be sought

Bottom Phase

It would appear that the time spent in this phase (theoretically 3–5 seconds) is already at a minimum although it needs to be emphasized that a few extra seconds delay can make all the difference between a successful escape and one resulting in decompression sickness

Ascent Phase

There has been considerable research into altering the pressure profile of the ascent The aim is to increase the speed of ascent in the early stages and reduce it in the later stages Three methods have been suggested [10,12] Doubling the length of the projectile would speed up the rate of ascent initially 1e by joining two escapees together They would split at a predetermined depth and continue their (separate) ascent at a slower rate Another alternative is to lengthen the suit with an inflatable extension which can be deflated or cast off at the appropriate depth The third proposal which has been tested successfully on minipigs is the deployment of drogues to slow down the later stages of the ascent All these methods would obviously complicate the escape and as yet remain unproven

SUMMARY

The likelihood of decompression sickness following a buoyant free escape from a submarine can be predicted from a mathematical model which uses the escape pressure profile to estimate the equivalent depth time and a subsequent calculation to produce a risk estimate the Depth Time Multiple Thus can only be an approximation for what is a very complex process and is unlikely to be valid for much deeper escapes Tissues which have the shortest half times for nitrogen uptake and release are still taking up nitrogen during the ascent and these tissues are the most critical in the genesis of decompression sickness in this situation Observation of current typical escape profiles suggests that the greatest contributor to the nitrogen uptake in the critical tissues is ascent time and there seems to be no simple way of decreasing this risk at present Time on the bottom is at a theoretical minimum in practical terms Reduction of the compression time would be advantageous although there are certain constraints on this One physiological constraint is the ability to equalise middle ear pressures whilst not interfering with lung pressure equilibration by closing off the airway The principal mechanical constraint is the ability of the hood inflation system to keep pace with the change in pressure in the escape tower

Pearson[13] concluded that freedom from decompression sickness for escapes deeper than 180 msw may be achieved more easily by manipulation of breathing mixtures prior to and during ascent. This is a matter beyond the scope of this paper as is the added hazard of escape from compartments where the pressure is above 1 bar prior to escape More research is needed on this latter subject as prior exposure to increased pressure will completely alter the assumptions which are made at present in the theoretical calculation of safe escape profiles

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J roy nav med Serv 1988 74 107–114

A simple test for the assessment of aerobic fitness

D J Smith, R J Pethybridge and A Duggan

Abstract

The relationship between physical fitness, anthropometric measures and the scores in three submaximal step tests have been evaluated in a group of 30 male subjects. Physical fitness was assessed as VO_2max measured directly during uphill treadmill running. Each submaximal exercise test was of six minutes duration and the heart rate recorded during the last minute (fH_4) constituted the test score. Significant negative correlations coefficients were found between VO_2max and each test score while lean body mass, gross body weight and body surface area were all positively correlated with VO_2max (l/min). The score in the least severe step test was included with anthropometric measures in multiple linear regression analysis for the prediction of VO_2max and a number of prediction equations were derived. It was found that when lean body mass is calculated from skinfold measurements and weight, VO_2max can be calculated from the equation

$$VO_2\text{max(l/min)} = 1.470 + 0.0614 \times \text{Lean Body mass} - 0.0131 \times fH_4$$

This equation accounts for 73% of the total variation of VO_2max. If lean body mass cannot be calculated a combination of gross body weight and age plus fH_4 gives the equation

$$VO_2\text{max} = 3.614 + 0.0349 \times \text{Weight} - 0.0177 \times fH_4 - 0.0161 \times \text{Age}$$

accounting for 66% of the variance. The test has the following advantages over those currently employed:

It is simple to administer requiring 6 minutes of stepping onto a 32 cm platform—the height of a gymnasium bench—20 times per minute.

Although ideally an assessment of lean body mass is required, gross body weight plus age is a good second best.

It is submaximal minimising the stress on the individual (mean heart rate achieved 121 beats per minute).

Its accuracy in terms of its ability to predict maximal aerobic power is better than either the Ohio or Harvard University tests.

It is suggested that this test could be used where maximal testing is contraindicated or where currently used tests are insufficiently accurate.

Dr Smith is Head of Applied Physiology and Dr Pethybridge is a statistician both at the INM. Dr Duggan is currently employed at APRE Farnborough.

INTRODUCTION

Physical fitness is a much quoted but often poorly understood topic. It is generally agreed that RN personnel should be sufficiently fit (a) to perform their tasks, (b) to act in emergencies, (c) to maintain their health and (d) to avoid injury when unaccustomed physical effort is required. The type and level of fitness to fulfill the above is still open to debate.

Physical fitness can be subdivided into a number of aspects according to the duration of the task:

(a) Muscular strength—the capacity to generate maximal contractile force for very brief tasks (<5 secs) such as lifting, holding, pulling and pushing.

(b) Anaerobic fitness—the ability to perform brief tasks (<60 secs) of high intensity.

(c) Aerobic fitness—the ability to perform heavy work for several minutes.

(d) Aerobic endurance—the ability to utilise a high percentage of one's aerobic fitness for several hours.

Aerobic fitness is always the most important of these as the aerobic system determines the

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It is simple to administer, requiring 6 minutes of stepping onto a 32 cm platform—the height of a gymnasium bench—20 times per minute.

Although ideally an assessment of lean body mass is required, gross body weight plus age is a good second best.

It is submaximal, minimising the stress on the individual (mean heart rate achieved 121 beats per minute).

Its accuracy in terms of its ability to predict maximal aerobic power is better than either the Ohio or Harvard University tests.

It is suggested that this test could be used where maximal testing is contraindicated or where currently used tests are insufficiently accurate.

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INTRODUCTION

Physical fitness is a much quoted but often poorly understood topic. It is generally agreed that RN personnel should be sufficiently fit (a) to perform their tasks, (b) to act in emergencies, (c) to maintain their health and (d) to avoid injury when unaccustomed physical effort is required. The type and level of fitness to fulfill the above is still open to debate.

Physical fitness can be subdivided into a number of aspects according to the duration of the task.

(a) Muscular strength—the capacity to generate maximal contractile force for very brief tasks (<5 secs) such as lifting, holding, pulling and pushing.

(b) Anaerobic fitness—the ability to perform brief tasks (<60 secs) of high intensity.

(c) Aerobic fitness—the ability to perform heavy work for several minutes.

(d) Aerobic endurance—the ability to utilise a high percentage of one's aerobic fitness for several hours.

Aerobic fitness is always the most important of these as the aerobic system determines the

rate of recovery from any type of exercise It is best measured by the assessment of maximum aerobic power i e the maximum amount of oxygen the body can utilise per unit time usually expressed as VO_2max l/min [1,2] A number of methods are currently employed to make this assessment generally utilising a treadmill or a bicycle ergometer Unfortunately direct measurement of VO_2max is time-consuming and requires complex and expensive equipment along with highly trained staff to run it Additionally this method requires maximal effort for several minutes by the subject and in unfit personnel carries a small medical risk It is not therefore possible to assess the VO_2max of large numbers of subjects on a routine basis An alternative but still maximal test is a timed run Distance running has been found to be a good predictor of VO_2max in a number of studies[2,4,5,6] but not in others [7,8] However tests of this type still require a high level of motivation and familiarity with distance running and carry the risk of any maximal test To counter the risks associated with maximal effort submaximal tests have been developed These indirect methods purport to predict maximal aerobic power most involve the measurement of heart rate during submaximal exercise Some involve a calculation of maximum aerobic power by extrapolation to the work which would have been possible at a predicted maximum heart rate others use a submaximal heart rate as an index in its own right Of these the majority are step tests, of which the most commonly used are the Ohio State University Test and the Harvard Step Test

Two groups of Naval personnel are currently obliged to undertake step tests for physical fitness assessment namely divers and aircrew The leadership training schools have recently discontinued the use of a step test as it helped little in predicting performance (see on) The two tests which have been employed are the Step Up To Physical Fitness Test (SUTPFT)—a modification of the Ohio State University Test described by Kraucz *et al* [16] and a modification (smaller step) of the Harvard Step Test [9] Both rely solely on pulse rates taken during the recovery from exercise. The Harvard test score is the sum of three 30 second pulse counts taken 1 to 1 5 2 to 2 5 and 3 to 3 5 minutes after a 5 minute exercise period The Ohio and SUTPFT consist of up to 18 work periods called innings of 30 seconds duration The protocol involves three groups (or phases) of 6 innings each differing in step height or frequency such that the physical effort required is increased after the 6th and 12 innings respectively Following each innings the subject stands motionless for 20 seconds whilst heart rate is recorded over 10 seconds This occurs after each third innings up to innings 12 thereafter following every innings up to the 18th Should the number of beats in this 10 second period reach 25 or more (>150 bpm) the test is terminated and the score for that individual is the number of innings completed The subject is then classified in fitness accordingly as between very poor (completed 6 innings or less) and very good/excellent (completed 17/18 innings)

No test can be considered adequate unless it can be shown to correlate strongly with directly measured maximum aerobic power The literature referring to the relationship between the results of the two tests mentioned above and directly measured VO_2max is relatively scant

The Ohio State University test[10] was initially validated against the Balke Treadmill Test described by Balke and Ware [11] Although a high correlation coefficient ($r = 0\ 94$) was found between the scores in these two tests [10] it should be noted that the Balke Treadmill test is itself an indirect and submaximal test of aerobic power Santa Maria *et al* [12] comparing the Ohio test with directly measured VO_2max obtained a correlation coefficient of 0 47 indicating that only 22% of the variance in VO_2max could be accounted for by the scores on this test The SUTPFT differs from the Ohio State University Test only in that the subject does not hold onto the hand rail during stepping Although submaximal terminating at a heart rate of 150 beats per minute it is complicated to administer and relies on short (10 second) pulse counts taken by palpation Extrapolation from such short pulse counts is likely to be prone to considerable error

The Harvard Step Test first described in 1943 [12] has been used widely over the years since then particularly by military forces Moderate correlations of between 0 55 and 0 77 (i e 30 to 59% of the variance) have been reported between test scores and VO_2max [13 14 15] The test imposes a very severe workload which is maximal for all but the fittest men Thus a group of marathon runners experienced soreness about the calf muscles and achilles tendon considerable local fatigue pain in the knee joints and soreness throughout the thigh groin and calf which persisted for several days after taking the test [16] and other groups reported

discomfort in the quadriceps muscle group [7] The Harvard Step Test is used by the Royal Navy in a modified form with a 17 inch rather than a 20 inch step but many of the problems remain and the test still imposes a maximal workload on many individuals

The Ohio and SUTPFT scores are the number of innings completed Fitter persons will achieve a maximum score and their fitness cannot therefore be separated by this test The Harvard test score is the total of three 30 second heart rates The least fit will be unable to complete this test and their fitness similarly cannot be separated Neither score gives an indication of VO_2max

Body composition has an important bearing on exercise capacity All other things being equal the greater the amount of muscle a body contains the greater the aerobic power and the greater the absolute VO_2max when expressed as litres of oxygen consumed per minute Simplistically at similar levels of training a 15 stone Tarzan will have a greater VO_2max l/min than a 9 stone weakling However when asked to race each other the result is not a forgone conclusion This is due to the relationship of aerobic power to body weight To take this into consideration VO_2max can alternatively be expressed as ml/kg body weight/minute This latter measurement gives a more accurate assessment of a person's ability to move his own mass Thus any non energy producing weight such as an excessive quantity of body fat, which has to be carried will reduce this ability Thus there is likely to be a clear negative correlation between body fat content and VO_2max ml/kg/min Several authors have reported a relationship of various anthropometric measures to both VO_2max[3,5,8,10,11] and step test performance[11,18] Neither of the two step tests discussed above take any anthropometric variables into account

In view of the disadvantages of the methods currently in use an alternative safe simple to administer test which gives a good correlation with directly measured VO_2max could be of use to the Royal Navy in the assessment of aerobic fitness A simple submaximal step test where heart rate recorded during the steady state exercise is used in association with such anthropometric variables as lean body mass to predict directly measured treadmill VO_2max should satisfy these criteria

METHODS

This paper describes the results of a series of investigations to determine which of three such tests each with a different severity exercise, and thus medical risk would give a reliable prediction of aerobic fitness with minimum risk.

In this study three step tests were assessed All were conducted after at least 15 mins rest with at least 30 mins between test All tests were of 6 minutes duration and pulse rate was recorded from the ECG during the last minute of exercise The test scores were taken as the 6th minute heart rate (beats per minute) abbreviated fH_6 The step tests A B and C consisted of stepping off platforms 32 35 and 38 cm high at 20 21 and 22 steps per minute respectively

Forty five subjects undertook the three step tests according to a 3×3 latin square design during one half day session and 30 of these volunteered to have their VO max determined

Body weight and height were recorded on subjects stripped to shorts and in bare feet Fat free mass and percentage body fat were calculated from skinfold thicknesses recorded with Harpenden calipers according to the method of Durnin and Wormersley[19] Body surface area was calculated from height and weight from the Dubois equation[20]

Maximal oxygen uptake was determined during uphill treadmill running using a continuous protocol Inspired volumes were calculated using a pneumotachograph and expired air analysed by mass spectrometry after passage through a gas mixing box Oxygen consumption was calculated after correction for temperature and the time lag of the mixing system The highest VO_2 recorded over a 30 second period was accepted as the VO_2max providing that this was not more than 100 ml/minute greater than that obtained at the previous work rate and that subjective exhaustion was attained

Data Analysis

Analysis of variance was used to test for the effects of order in which the step tests were conducted and to determine whether the fH_6 responses to the three step tests differed significantly For those 30 personnel who performed both the VO_2max and the step tests simple statistical measures (means standard deviations and ranges) were calculated for VO_2max the exercise test scores and anthropometric factors

The correlation coefficients (r) between pairs of variables were determined and these were tested for significant difference from zero fol-

lowing application of the Fisher z transformation. A multiple linear regression model relating VO_2max to the score in test A (fH_RA) and anthropometric factors was developed. The regression estimation procedures for inclusion or deletion of variables to the model are outlined by Draper and Smith [11]. The coefficients of determination (R^2) between observed and predicted VO_2max were calculated from the regression equations. Statistical significance was accepted as $P<0.05$.

RESULTS

Comparison of Tests A, B and C

Significant differences between fH_R in the three tests were found. There were no order of testing effects. The mean, range and standard deviation of fH_R in each of the exercise tests are presented in Table 1. Test A elicited the lowest mean heart rate (121 beats/min) and Test C the highest (139 beats/min). The highest heart rate recorded in any subject in any of the tests was 172 beats/min. The mean VO_2max of the 30 subjects measured was 3·51 l/min (50·5 ml/kg/min).

Table 2 presents the correlation coefficients between pairs of variables. Significant negative correlations were found between fH_R in each test and VO_2max, expressed either as l/min or ml/kg/min. The more strenous tests failed to elicit stronger correlations than Test A. No improvement in the strength of the relationship was obtained by averaging the three step test scores. Further analyses were therefore restricted to the least severe test, Test A.

Reproducibility of Test A

To assess Test A reproducibility, the test was repeated on 12 individuals on two separate days. The mean heart rate difference between the two tests was only 1·5 beats/minute and the mean of the modulus of the differences between the test and retest scores was 7·8 beat/minute. Over 90% of the retest scores were within 10% of the score in the first test.

Correlation of VO_2max with Test A fH_R and anthropometric variables

Correlation coefficients between VO max, test scores and anthropometric factors were calculated. Significant positive correlations of 0·62, 0·76 and 0·60 were found between VO_2max (l/min) and body weight, lean body mass and surface area respectively and a significant negative correlation of −0·59 between VO_2max (ml/kg/min) and percent body fat. Age and height were not significantly correlated with VO_2max, but age correlated positively (0·40)

Table 1 Sixth Minute Heart Rates (fH_R) during physical fitness tests

	fH_R (beats/minute)		
Test	Mean	Range	Standard Deviation
A (32 cm × 20/minute)	121	91–151	15·2
B (35 cm × 21/minute)	129	105–158	14·8
C (38 cm × 22/minute)	139	104–172	16·3

Table 2 Correlation between Step Test Scores and VO_2max

	VO_2max	
	l/min	ml/kg/min
fH_RA	−0·56**	−0·53**
fH_RB	−0·42*	−0·48*
fH_RC	−0·44*	−0·55**

* Significant at $P<0.05$
** Significant at $P<0.01$

with % body fat Table 3 presents the correlation matrix for selected factors.

Multiple Regression Analysis

Lean body mass gross body weight height and age were included with the score in step test A in multiple regression analyses for the derivation of formulae for the prediction of VO_2max (l/min) A high correlation with VO_2max was obtained using fH_E and lean body mass together ($r=0\ 86$ $R^2=0\ 73$) This is a considerable improvement on lean body mass alone ($r=0\ 76$ $R^2=0\ 58$) and a marked improvement on the heart rate score alone ($r=0\ 56$ $R^2=0\ 31$) Eighty seven per cent of values predicted by this equation were found to be within 10% of the observed values for the subjects Given lean body mass and fH_EA in the prediction equation none of the factors body weight age or height added significant contributions to the relationship with VO_2max

For situations where it would be impossible to assess lean body mass, regression analysis incorporating gross body weight instead were carried out. The correlation between VO_2max observed and VO_2max predicted from fH_EA and body weight was estimated to be 0 76 ($R^2=0\ 58$) With these factors in the equation age became a significant factor improving the correlation to 0 81 ($R^2=0\ 66$) The multiple linear regression equations for prediction of VO_2max (l/min) are given in Table 4

DISCUSSION

Comparison of Step Tests A B and C

All three step tests proved to be submaximal as was evidenced by the finding that the nearest any subject's fH_E came to his age-predicted maximum heart rate[32] was 26 beats per minute This occurred during test C the most severe test However it should be pointed out that even the two least fit subjects in this study would be graded as no worse than "fair" (VO_2max in range 33 8 to 42 6 ml/kg/min) according to the classification of cardiovascular fitness proposed by Cooper [4] while the rest of the subjects would be classified as "good or excellent" With less fit subjects it is possible that test C could be maximal Therefore Test A, the easiest step test which elicited a mean

Table 3 Correlation Matrix for VO_2max Fitness Test Score Age and Anthropometric Factors

		1	2	3	4	5	6	7	8
1	VO_2max (l/min)								
2	VO_2max (ml/kg/min)	0 68**							
3	fH_E (beats/min)	−0 56**	−0 53**						
4	Age (yrs)	−0 10	−0 18	−0 03					
5	Weight (kg)	0 62**	−0 14	−0 20	0 05				
6	Lean (body wt kg)	0 76**	0 11	−0 24	−0 14	0 91**			
7	Fat (% body wt)	−0 06	−0 59**	0 02	0 40*	0 54*	0 15		
8	Surface Area (m_2)	0 60**	−0 03	−0 24	0 01	0 87*	0 77**	0 51**	
9	Height (cm)	0 22	−0 21	0 00	0 08	0 52*	0 052**	0 18	0 02

* Signif cant at $P<0\ 05$
** Signif cant at $P<0\ 01$ n=30

Table 4 Multiple linear regressions for the prediction of VO_2max

Constant	Lean body mass kg	fH_EA beats/min	Weight kg	Age yrs	R^2
1 470	+0 0614	−0 0131			0 733
1 624	+0 0891	−0 0138	−0 0230	−0 0042	0 766
1 256	+0 0979	−0 0129	−0 0256		0 764
2 856		−0 0148	+0 0351		0 581
3 614		−0 0177	+0 0349	−0 0161	0 656

R^2 is the proportion of the total variation accounted for by the equation

fH_R of only 121 beats per minute would seem to be the best choice since it should be submaximal for even the least fit of naval personnel and yet yielded a similar correlation between fH_R and VO_2max as Tests B and C. Furthermore the test retest data indicate that Test A is a reliable test

Correlation of VO_2max with anthropometric variables

The significant correlation coefficient (r) of 0 62 between body weight and VO_2max (l/mtn) in this study is similar to that obtained in a number of other studies An r of 0 63 has been reported for a heterogeneous group of 54 healthy students and soldiers [18] Jessup *et al*[7] give a value of 0 57 for a group of 40 male PE students and Welch *et al*[20] a value of 0 59 for a group of 28 young men attached to the US Army Medical Nutritional Laboratory Higher correlations have been reported in a group of 35 untrained young men in the USA where r was 0 71[2] and in 44 college males aged 17–30 years (r=0 74) [3] However in a group of 23 healthy young British male factory workers Cotes *et al* [5] was unable to show a significant correlation (r=0 37) These differences could be methodological or might represent genuine differences between the populations used Davies[28] carried out a study on 88 Royal Naval officers and ratings to investigate the relationship between VO_2max and body composition A subgroup of these consisting of 22 men less than 36 years old was of almost identical fitness status to the group of subjects used in the study reported here mean VO_2max 3 52 l/min (51 0 ml/kg/mtn) compared with 3 51 l/min (50 5 ml/kg/mtn) in this study In his young subgroup Davies reported significant correlations of 0 53 and 0 50 between VO_2max (l/mtn) and body weight and height respectively In contrast height was not found to correlate significantly with VO_2max in either this study or in that of Jessup *et al* [7] or indeed in Davies older subgroup [28]

Buskirk and Taylor[18] reported a correlation coefficient of 0 85 between lean body weight and VO_2max A high correlation (r=0 76) was also found in this study Using different techniques for estimation of lean body mass lower correlations were found by Hermiston and Faulkner[21] (r=0 68 in 36 inactive subjects and r=0 48 in 36 active subjects) Welch *et al*[22] (r=0 65) and Davies[28] (r=0 41 in his older group non significant in his younger group)

Correlation of VO_2max with Age

Astrand and Rodahl[33] have reviewed the literature on the effects of ageing on VO_2max It has been reported that VO_2max is at its peak in subjects aged 18 to 20 years and that there is a gradual but very variable decline from that age onward The correlation between age and VO_2max in this study was as expected negative but it was not found to be significantly different from zero The low valued correlation was probably the result of a combination of factors namely the large variation in VO_2max in each age group the small number of subjects tested and the variability in the loss of VO_2max with age

Multiple Regression Analysis

Much better predictions of VO_2max were made from multiple linear regression equations than from any of the exercise scores or anthropometric measures alone The high degree of correlation between the exercise test scores indicated that only one needed to be included in a model estimating the relationship between VO_2max and other factors Test A was chosen for the reasons given earlier Weight and lean body mass were highly correlated (r=0 91) and consequently little advantage was gained from filling both of these in a formula for the prediction of VO_2max. Height was not found to be a significant factor Although one could suggest that step height should be linked to height (or at least to leg length) on submaximal tests using small boxes such as those described changes in efficiency are unlikely to be of importance Body surface area as it was calculated from height and weight and therefore correlated strongly with both was not included in the equation

Lean body mass would appear to be the major predictor of VO_2max (l/min) as is indicated by the high correlation (r=0 76) and the finding that 73% of the variation in VO_2max could be accounted for by lean body weight and fH_RA alone (r=0 86) That such a high correlation was observed from an equation incorporating both of these variables compared with each one separately indicates that they contain information on different aspects of the VO_2max It is suggested that fH_R mirrors the capacity of the cardiovascular system for transporting oxygen to the tissues while lean body mass gives an indication of the capacity of the body for oxygen utilisation during exercise The finding that age becomes a significant factor in the

Table 5 Comparison of INM Test with Harvard and Ohio Step Tests

	Regression Coefficient (R^2) of VO_2max with test scores
OHIO Step Test	0 22
HARVARD Step Test	0 30 to 0 59
INM Test (with fH_R and Lean Body Mass)	0 73
INM Test (with fH_R Weight and Age)	0 65

For references see text

prediction of VO_2max when lean body mass is replaced by weight is probably due to the significant correlation found between age and % body fat ($r = 0.40$)

Comparison of INM Test with Harvard and Ohio Tests

The test discussed in this paper appears to have all the attributes of a practical test It is simple submaximal and requires minimal equipment It outperforms the Ohio and Harvard tests in terms of its ability to predict VO_2max (See *Table 5*) and gives a meaningful result (predicted VO_2max l/min) rather than an arbitary test score

CONCLUSIONS

A simple submaximal reliable fitness test has been developed which incorporates anthropometric factors into an equation with a heart rate score obtained during low intensity box stepping Good predictions of VO_2max (l/min) have been made in a group of 30 subjects from a regression equation including heart rate weight and age and even better predictions from a formula including heart rate and lean body mass The generation and validation of further equations to predict VO_2max (ml/kg/min) and running performance will be the subject of a further report.

ACKNOWLEDGEMENTS

This paper is based in part, on the results of a preliminary study conducted by Evans *et al* [14]

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J roy nav med Serv 1988 74 115–120

Step Testing as an assessment of physical fitness on Polaris submarines

J Berth-Jones and D J Smith

Abstract

The fitness of 22 volunteers was assessed at the beginning and end of an SSBN deterrent submarine patrol using the Modified Harvard and Step Up to Physical Fitness tests. This provided a means of evaluating both the value of step tests and the fitness of a sample of the crew.

The overall level of fitness of the group was high and did not change significantly during the patrol.

The step tests appear suitable for the purposes for which they are employed but unsuitable for the assessment of outcomes of fitness. They could be replaced by a simpler, shorter and safer test.

INTRODUCTION

The use of step tests has been accepted in the Royal Navy as a method of determining fitness to dive or commence leadership courses the accuracy of these tests is therefore considered important both to the Royal Navy and to the individuals to whom they are applied.

It was therefore decided to assess the effectiveness of these tests by using them to investigate physical fitness of the crew of an SSBN (Polaris) submarine. Previous work has tended to show a small but significant drop in fitness while at sea [1]. If this fall is repeated during a number of patrols it may lead to a progressive and excessive decline in the fitness of the crew.

Twenty two volunteers from the crew of SSBN HMS/M *Repulse* (Port) were given step tests at the beginning and end of an eight week patrol. Information was obtained on

1 The overall level of fitness of the volunteers

2 Changes in fitness during patrol

3 The effects of exercise before and during patrol on the above.

The opportunity was taken to assess whether the step tests currently in use could be replaced by a simpler, shorter and safer test utilising an electronic pulse meter to eliminate errors due to pulse counting by non medical personnel.

Dr Berth Jones is on the Emergency List. Dr Smith is Head of the Applied Physiology Division at the INM.

METHOD

Subjects

The subjects were true volunteers from the officers and ratings of the submarine who responded to a request posted on a notice board. Twenty-three subjects volunteered and only one dropped out during the trial claiming that he was too busy to participate.

All subjects underwent the Modified Harvard Test (MHT) and Step up to Physical Fitness Test (SUTPFT) at the beginning of the patrol and the MHT SUTPFT and Institute of Naval Medicine (INM) step test at the end of the patrol.

All subjects were asked whether they had participated in regular exercise during the two months preceding the first set of tests while ashore and again before the final set of tests whether they had taken regular exercise while at sea on patrol. Regular exercise was defined imprecisely as the participation in a sport or activity providing exercise excluding duty at least once a week. Those who answered 'yes' to this question therefore filled a wide spectrum ranging from those who while ashore played football or squash once a week to those who

undertook daily weight training or running and from those who while at sea spent 10 minutes weekly on the exercise bicycle to those who maintained intensive training programmes

Statements made concerning exercise habits at sea were easily verified by the observation of the Medical Officer and it is not considered likely that any subject was deliberately misleading about the stated exercise pattern

STEP TESTS

The Modified Harvard Test (MHT)

This was performed as for a routine diving medical The test consists of step ups at a rate of 30 per minute to a height of 43 cm (17 inches) for 5 minutes Three 30 second pulse counts are taken at 1 2 and 3 minutes after completion of the step-ups and the score is the sum of these three counts The pass mark used for a diving medical is 190 or less [3]

The Step Up To Physical Fitness Test (SUTPFT)

This was performed in accordance with its use to detect candidates who were unfit for Leadership Courses at HMS *Royal Arthur* It is a much easier test for the subject as it is terminated as soon as the heart rate is found to exceed 150 beats per minute It is therefore also safer than the MHT The subject alternately performs step-ups for 30 seconds and rests for 20 seconds each of these 50 second periods being termed an innings The first 6 innings are performed with a step rate of 24 per minute to a height of 38 cm (15 inches) The next 6 are performed with a faster step rate of 30 per minute and the last 6 at a rate of 30 per minute to an increased height of 51 cm (20 inches) Ten second radial artery pulse counts are performed at the middle of the 20 second rest periods after the third sixth ninth twelfth and each subsequent innings The test is terminated when this count exceeds twenty-five (i e the heart rate exceeds 150 beats per minute) The score is recorded as the number of completed innings [4]

The INM Test

This experimental test is simpler shorter and less strenuous than either the MHT or the SUTPFT It consists of a six minute period of step ups at the rate of 20 per minute to a height of 32 cm Heart rate is recorded during the final minute of exercise This heart rate is then entered into a regression equation with the subject's anthropometric data to generate a predicted VO_2max Lean body mass or percentage body fat obtained from skinfold thicknesses are the preferred anthropometric variables but it has been shown that by using total body weight and age a fairly good correlation with VO_2max is obtained [5] It was not possible to weigh subjects at sea with the equipment available thus weight had to be obtained from medical documents

The following formula was used

$$VO_2max = 3.614 + 0.0349 \times \text{Body Weight} - 0.0177 \times fH_6 - 0.0162 \times \text{Age}$$

where VO_2max is expressed in l/min body weight in kg and age in years fH_6 is the heart rate (in beats per minute) recorded during the sixth minute of the test

The Pulse Meter

MHT and SUTPFT heart rates are recorded at rest The INM test however requires that an exercising pulse be recorded An attempt was made therefore to assess the suitability of a Boso Card II pulse meter for use in operational conditions as a means of eliminating errors due to radial pulse counting by untrained personnel

A transducer is clipped to the ear lobe and light passes through it to detect capillary pulsation The meter displays a pulse rate derived from the number of pulsations recorded over the previous eight seconds An additional feature of the device allows alternative displays of time (a stopwatch facility) with pulse rate each display lasting for five seconds This feature was used during the INM tests and the pulse rate displayed at the end of the five second displays during the last minute of exercise was recorded The six pulse rate readings thus recorded were then averaged to obtain a pulse rate over this minute. The cost of the device was only £75 so it may not be too expensive to issue to ships and establishment sick bays for use in routine medical examinations

General Factors

Each subject was kept seated for a thirty minute period before each test The initial series of tests was completed during the first two weeks of patrol and the second series during the final two weeks

Exercise facilities available on board included a rowing machine exercise bicycles a set of weights and a treadmill like device for

jogging on the spot (The subject jogs along a set of rollers holding onto a bar in front of him)

Safety

Safety precautions taken prior to the trial comprised a clinical assessment of each subject by the Medical Officer and an ECG No volunteers were turned down on health grounds

RESULTS

The mean age of the volunteers at the end of the patrol was 26 6 years range 18 to 35

From the exercise questionnaire subjects were divided into four groups as shown in Table 1

The mean score for the MHT was 185 at the start of patrol and 179 at the end of patrol The mean value for the SUTPFT both at the start and end of patrol was 12 innings The mean heart rate recorded at the end of patrol on the INM test was 128 beats per minute Utilizing the regression equation this gives a mean predicted VO_2max of 47 2 ml/kg/min (range 39 2 to 53 9 for the 22 subjects) Table 2 shows these results expressed as passes and fails for Diving and Leadership courses

Changes in fitness are summarised in Table 3 As a number of subjects showed alterations in the MHT score of less than five points an additional set of data was calculated using 5 or more points as the minimum required to identify a change in fitness

It is therefore suggested that there was no overall change in fitness revealed by either test amongst the volunteers for the trial

To investigate whether there were changes within the exercise groups groups were broken down as shown in Table 4 The magnitude of these changes are shown in Table 5

Table 1 Subject groupings according to exercise category

	Group	Exercise Ashore before Patrol	Group	No Exercise Ashore Before Patrol
Exercise at Sea	A	n=4	B	n=7
No Exercise at Sea	C	n=3	D	n=8

Table 2 Fitness as assessed by diving and leadership training standards

	Initial Test		Final Test	
Diving fitness screening test	Pass	11	Pass	11
	Fail	11	Fail	11
Leadership course screening test	Pass	20	Pass	20
	Fail	2	Fail	2

Table 3 Changes in Fitness during Patrol

TEST	Number of Subjects who at the end of Patrol were		
	More Fit	Same	Less Fit
SUTPFT	6	10	6
MHT	13	1	8
MHT (>5 point change)	10	6	6

Table 4 Changes in Fitness during patrol by Exercise Group

Group	No of Subjects	Number of Subjects who at the end of patrol were: More Fit		Same		Less Fit	
		MHT	SUTPFT	MHT	SUTPFT	MHT	SUTPFT
A (Ex ashore and at sea)	4	2	1	2	3	0	0
B (Ex at sea)	7	5	3	1	2	1	2
C (Ex ashore)	3	1	1	1	0	1	2
D (No Exercise)	8	2	1	2	5	4	2

Table 5 Magnitude of changes in Fitness during patrol

Group	No of Subjects	Change in MHT during patrol		Change in SUTPFT during patrol	
		Average	Range	Average	Range
A (Ex ashore and at sea)	4	−10 8	−22 to 0	+1 5	0 to +6
B (Ex at sea)	7	−16 1	−64 to +27	+1 4	−3 to +7
C (Ex ashore)	3	+2 3	−9 to +12	+0 7	−1 to +4
D (No Exercise)	8	+1 8	−18 to +22	−1 1	−6 to +3

These figures reveal a general tendency for those who exercise at sea to maintain or increase their fitness (groups A and B) whereas those who do not tend to maintain or lose their fitness

Additional analysis on the changes in MHT during the patrol has been conducted by undertaking a one way analysis of variance to assess if the groups A B C and D were similar or not The results of the analysis indicate that the average changes for the groups were not significantly different

DISCUSSION

The level of fitness of volunteers as determined by these tests was encouragingly high Whether this represents an adequate level of fitness for a submarine crew is a matter of conjecture the authors are aware of no evidence that a high level of physical fitness is required for the efficiency of a submarine crew and would certainly not maintain that a submariner need be as fit as a diver or a leading hand about to undertake a strenuous leadership course

Extrapolation of the results in the volunteers to the crew in general cannot be made without a further study examining a larger section of the crew selected at random

Motives for participation in the study were varied Most subjects appeared simply to be interested in discovering how fit or unfit they were Two subjects were due to undertake Leadership Courses in the immediate future and were therefore keen to see if they would pass the necessary test The keep fit enthusiasts were a small minority 2 in number appearing in group A No pressure was put on any member of the crew to participate in exercise during this patrol an no organised exercise sessions of any sort took place The levels of exercise undertaken by the crew are therefore believed to be typical of a routine deterrent Patrol

The absence of any demonstrable change in the overall level of fitness may indicate that fitness is maintained by the level of activity involved in routine duties on board Numerous firefighting exercises and similar events took place during the patrol involving the rapid shifting of large amounts of equipment around the boat A large amount of energy was also expended keeping the boat clean For many of

the crew this may represent more than their normal exercise level when ashore

There is a suggestion however that those who exercise on board may become fitter whereas those who do not may become less fit and these changes if they are real may be masked if the results are averaged over the whole ship's company

When the tests are considered the sinking difference between the MHT and the SUTPFT is the range of fitness over which they will discriminate between subjects The SUTPFT has a maximum score of 18 and as two subjects reached this in both their initial and final tests neither their relative fitness nor any change in their fitness level could be assessed using this test.

The MHT in contrast can define fitness up to the fittest end of the range but for the unfit it constitutes an horrendous ordeal as they begin to stumble over the bench performing with ever decreasing efficiency with heart rates in some cases exceeding 180/min one minute after the end of exercise For obvious reasons the SUTPFT is far safer than the MHT

One subject proved unable to pass either the MHT or the SUTPFT at the end of patrol in spite of a very intense exercise programme both before sailing and while at sea He was able to perform a high rate of exercise however and had no difficulty completing the MHT It is considered that this was due to elevation of his pulse rate by anxiety and that this may be a limitation in this form of test

The MHT and SUTPFT scores correlated with an r value of 0 77 at the beginning of patrol and 0 76 at the end—a surprisingly good correlation in view of the limitations described earlier Thus it would be possible to substitute the more strenous MHT by the safer SUTPFT using a higher pass mark of perhaps 12 innings to assess fitness of divers Thus pass mark appears to correspond to the score of about 190 in the MHT This substitution may be desirable purely on the grounds of test severity

The predicted VO_2max obtained by the INM test at the end of patrol showed a significant correlation with both the MHT (r=0 65) and the SUTPFT (r=0 76) The degree of correlation is undoubtedly reduced by the maximal score of 18 in the SUTPFT and the poor discrimination of the Harvard test between severely unfit individuals whose heart rate is maximal It is not to be expected that the INM test would correlate closely with either of the others—they do not measure precisely the same thing Both the MHT and the SUTPFT use recovery pulses whereas the INM test uses an exercise pulse and takes anthropometric data into account in an attempt to derive a more precise physiological measure of aerobic fitness—namely VO max

The INM test had the following advantages over the tests currently used

1 It avoids strenuous exertion in subjects who are unfit

2 It has no obvious limitations as to the range of fitness over which it remains accurate

3 It takes only 6 minutes to perform

4 It is simpler to perform and therefore less subject to errors of technique timing of pulse counting by unskilled individuals (In the SUTPFT candidates at HMS *Royal Arthur* often count each other's pulses)

An essential factor for the use of a test of this type is the development of a reliable means of measuring pulse rate while the subject continues to exercise The pulse meter was found to have many limitations If it fails to count one heartbeat or counts one too many the pulse rate calculated over the next 8 seconds will be very inaccurate. Observation of the reading on the instrument indicated that, while this does not happen at rest when the subject begins to exercise the pulse rate appears to fluctuate to a much greater degree than is actually occurring. This necessitated some tests being abandoned and repeated later Possible explanations for these inaccurate counts include movements of the head leading to fluctuations in tension of the wire to the transducer and consequent artificial fluctuations in capillary blood flow In order to try and prevent this the wire was pinned to the subject's shirt collar The pulse meter was not however found sufficiently reliable for accurate heart rate counting during box stepping

Other methods tried during the patrol included a radial pulse count found to be very difficult in a moving subject and an ECG recording This did not prove practical using the portable Cambridge Transrite ECG machine carried on board but would be feasible with more sophisticated equipment Further possibilities would include phonocardiography a pulse meter with a more rapid response so that artefacts could be readily identified a meter with a slower response so that artefacts would induce a less significant change in result, or counting a radial pulse on stopping exercise This last option is being investigated at the

INM. Overall the INM test does appear to have the potential to replace both the others if a good pulse counting technique can be evolved.

CONCLUSIONS

The overall level of fitness of the volunteers was relatively high with an average predicted VO_2max from the INM test of 47 ml/kg/min and it is encouraging to find that 50% of them surpassed the diving medical fitness standard and all but two the HMS *Royal Arthur* Leadership Course standard. During the patrol there were no overall changes in the level of fitness some subjects becoming fitter and others less so. Those taking exercise at sea were more likely to increase their fitness whereas those subjects who took no exercise at sea were more likely to lose fitness. However several subjects in both groups showed no change in their fitness levels at all. The exercise pattern of the subjects appeared to the Medical Officer to be fairly representative of that of the whole crew. The patrol was in all respects a routine one with no unusual physical activities onboard.

The Harvard and Step Up To Physical Fitness tests appear appropriate to the subjects for whom they are normally used but they are less accurate when the SUTPFT is applied to very fit subjects and when the MHT is applied to very unfit subjects. There is no reason why the safer SUTPFT should not be employed for diving medicals (with a higher pass mark than for leadership courses). Ideally however no step test should be employed other than as a crude fitness screen, or to measure changes in fitness or group fitness until it has been validated against a standard such as directly measured VO_2max or a timed run. It appears that the simpler and shorter INM test which has been shown to correlate well with directly measured VO_2max [5] could replace both these tests but more development will be required before this can be recommended.

None of the tests is infallible and it is possible for even fit subjects to fail them. It is therefore suggested that there will always be a need for discretion to be exercised by a Senior Medical Officer in these circumstances.

ACKNOWLEDGEMENTS

The authors would like to thank the officers and crew of HMS/M *Repulse* (Port) and especially those who volunteered for the trial for their eager and enthusiastic co-operation.

Further assistance was provided by Mr A. Duggan (physiologist) who performed the initial statistical analysis of the results and Dr R. J. Pethybridge who gave valuable statistical advice.

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5 Duggan A. & Smith DJ. Development of a regression model for the prediction of maximum aerobic power. In Proceedings of the 4th meeting of NATO Panel VIII RSG4 "Physical fitness with special reference to military forces". Brussels September 1983.

Authors note: Since submission of this paper the use of the Step up to Physical Fitness Test at RN Leadership training schools has been discontinued. This decision was taken on the grounds of its inability to predict subsequent physical performance.

Association of Service Physicians

The ninth Annual Meeting of the Association of Service Physicians was held at the Royal Army Medical College Millbank on 19 February 1988 fifty members attended

Chairman for the first session was Surgeon Captain A R. Marsh Director of Naval Medicine Following an introductory welcome by Major General R Scott, Commandant and Post Graduate Dean Royal Army Medical College, Flight Lieutenant R J Gregory presented a paper on the Role of Magnetic Resonance Imaging in the diagnosis of Neurosarcoidosis with a review of four cases Surgeon Commander W M Edmondstone gave an account of his experience of fibre optic thoracoscopy under local anaesthesia and its value in achieving a positive diagnosis in cases of pleural effusion when previous examination of pleural fluid and biopsy by Abrams needle had proved inconclusive Squadron Leader N A Harrison then presented a paper on the value of the urinary dipstick in assessing proteinuria suggesting that + or more on the dipstick correlated with abnormal proteinuria (150 mgs/24 hours or more) in 88% of cases Trace values straddled levels of significance though a subsequent negative result on repeat testing of a further sample later in the day correlated with normality in all but 5% of cases

Major General M Brown Director of Army Medicine took the chair for the second session which opened with a paper by Surgeon Commander R E Ashton describing his work to develop a programme for Computer Aided Diagnosis in Dermatology designed for use in areas where specialist dermatological opinion is not readily available Squadron Leader P E Stevens then gave an account of Acute Acalculous Cholecystitis occuring in patients with acute renal failure He drew attention to the considerable mortality of the condition gave guidelines for diagnosis and discussed methods of treatment particularly cholecystotomy

In the final paper Lieutenant Colonel J G Dickinson gave a review of Asthma in the Army with particular reference to discharges from the service and bedded sickness rates due to asthma during the period 1983/1986 He drew attention to the problem of recruiting at 16/18 years the age at which many childhood asthmatics are most likely to be between remission in their early teens and relapse in their early 20s There followed a period of animated discussion and the meeting concluded with lunch in the RAMC HQ Mess

BOOK REVIEWS

Tbn Control of Disease in tbn Tropics 5th Edition Davey and Lightbody (revised by David Stephenson) H K Lewis London 1987

This is a wonderful book It should not be regarded as a textbook of tropical medicine but as a practical guide to the control of disease in the tropics In practice most tropical disease is due to infectious agents either because of poverty leading to poor hygiene or because many of the tropical parasites have a temperature dependent life cycle and are not found in temperate regions Therefore this book gives great emphasis on the control of communicable diseases The first few chapters give some general points and definitions in the discussion of common cable disease and I have rarely seen these general principles expressed so simply

Individual diseases are then discussed under the general headings of those conditions associated with poor hygiene those caught by close contact disease spread by arthropods and finally the zoonoses The causative agent of each disease is briefly described together with the basic clinical features and therapy but then the substance of each section is a full discussion of practical public and individual health measures to contain the spread of disease

Further chapters go on to discuss the problems of administration and disposal of human waste and of course malnutrition will accumulate many of the problems of infection Again practical solutions are offered as far as possible although obviously the authors aims overwhelmed as we all are by the scale of the problems encountered in the tropics There is a useful chapter on basic statistics

Unfortunately this book was not available in any up dated form when I did the course for the diploma in tropical medicine and hygiene but it will now undoubtedly become a standard text and should be readily available to anyone who is intending to work in the tropics be they doctor nurse or paramedic

AROM

Trauma Imaging in the Thorax and Abdomen Alexander Rosenberger Olga B Adler and Rosalind H Troupin 259×182 mm Pp xx+155 Chicago, USA Year Book Medical Publishers (Distr Wolfe Medical Publications Ltd London) 1987 Hardback £36 50

This slim volume is dedicated entirely to the imaging of trauma victims and draws on the experiences of the staff of the Rambam Medical Centre in Haifa during the Middle East wars coupled with significant American input

There is no introductory overview which deals with imaging methods as well as mechanisms and results of different types of trauma The main portion of the book is divided into 8 chapters by anatomy These deal in a logical way with the many types of trauma their results and the imaging thereof Pitfalls and comparisons of imaging methods are also discussed where appropriate

The illustrations are numerous and in general of good quality if at times a little too small This results in some heavy points not being immediately obvious to the reader There is also heavy dependence on CT scanning a reflection of the facilities available to the authors but not necessarily to others

Overall I thought this little book useful and well laid out volume which is both easy and enjoyable to read It will however inevitably be of more practical value to those who have ready access to CT scanning.

XXX

Road Accident Statistics By Dr T P Hutchinson This remarkable hardback publication is more akin to a university masters thesis than the conventional textbook to which we have become accustomed

It is presented in clear double-column large print with a wide variety of typefaces to facilitate the presentation of such a colossal amount of data As tables form such an integral part of the book I would have liked to see the use of lines and boxes on many more occasions to allow the eye to read easily across several columns of data The detailed chapter contents list is excellent and the index is presented in an unusual format viz. by chapter by subsection and by figure or table This most of printing such a publication

is high but by ordering direct from the publishers (the sole suppliers) the price is held to a reasonable level for a foreign medical text

This is most definitely not a text for an individual doctor to purchase because it is simply not a book to be read as such and is quite literally for reference only but providing this is kept in mind the data will probably appeal to a wide audience There are two excellent sections on the Abbreviated Injury Scale (AIS) and the ICD E-code and the author s suggested improvements. I was rather disappointed that there was no dedicated chapter given over to the author s interpretation of the data (which has clearly been so painstakingly accumulated) and some conclusions drawn from such a discussion

This book will be available in the main hospital library and medical officers should be aware of its existence for future reference and as an example of research into a specialised topic it is outstanding.

MS

CHARITY COMMISSION

Charity The Journal of the Royal Naval Medical Service

The Charity Commissioners propose to make a Scheme for this Charity Copies of the draft Scheme may be obtained from them (Ref 154058 CD(SC)) at St Alban s House 57 60 Haymarket, London SW1Y 4QT Objections and suggestions may be sent to them within one month from today

LETTERS TO THE EDITOR

Sir

HISTORICAL NOTE

Very often an historical article can be rendered useless for reference purposes by the subsequent changing of building titles for quite legitimate administrative purposes.

One such article is The Modernisation of Haslar [1] the basis of which was the Block numbering system used at Haslar for 200 years.

All this has now changed and a sequential numbering system commencing from the new Main Entrance has been introduced so for the benefit of future historians the present and past designations are as follows

A Block was formerly E Block
B Block was formerly F Block
C Block was formerly B Block
D Block was formerly A Block
E Block was formerly C Block
F Block was formerly D Block

C T PARSONS

1 Parsons CT The Modernisation of Haslar *J roy nav med Serv* 1986 72:107–110

Sir

TESTICULAR TUMOURS—SELF EXAMINATION

1 A significant number of patients continue to present from the Royal Navy with testicular tumours. This is related to the age of the serving population which is the population at risk and with the emerging increase in the incidence of the condition nationally.

2 A 15 year experience in the management of testicular tumours within the Royal Navy has been reported to this Journal [1]. Posters were distributed for display in all Sick Bays ashore and afloat by the Office of Surgeon Rear Admiral (Support Medical Services) in conjunction with Surgeon Rear Admiral (Operational Medical Services) at the request of the Head of Urology and the Adviser in General Practice [2].

3 Three patients have presented with proven testicular tumours as a consequence. The early diagnosis and modern management of small volume disease is compatible with normal survival and retention within the Service.

4 The assistance of all Medical Officers is acknowledged and it is requested that their support for this self-examination be continued.

I have the honour to be

Sir

Your obedient Servant

I L JENKINS
Surgeon Commander RN
Consultant Urologist and
Professor of Naval Surgery

REFERENCES

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2 761/42/SRA(SMS) dated 29 October 1986.

EXERTIONAL HYPERPYREXIA

Recent articles on Exertional Hyperpyrexia and allied conditions published in the Journal and elsewhere have provoked vigorous debate in the RNMS and in the correspondence columns of the LANCET. It is planned to return to the topic in this section of the next issue. In the meantime Surgeon Commander Ian RIDDELL (CTCRM) has written reporting that his experience of treating cases in UK leads him to emphasise the vital importance of instituting immediate intravenous therapy using normal saline so that the peripheral circulation upon which other cooling mechanisms depend for their effectiveness is maintained.

Ed.

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OBITUARIES

Mark Andrew Rugg-Gunn MA MD FRCP Surgeon Captain RN

His daughter Dr Bridget Hood writes

Mark Andrew Rugg Gunn was born in Ullapool Ross-shire on 2nd August 1908 His father then in general practice was to become an eminent eye surgeon After a childhood spent in Scotland and India he was schooled at the Dragon School, Oxford Sherborne School Dorset and thence to St John's College Cambridge and St George's Hospital London He qualified in 1934 having won the Thompson Medal in Medicine in 1932 MRCP followed in 1940 and in 1946 he obtained his MD on Nutritional Neuropathy in Returning Japanese POWs He was elected FRCP in 1958 He entered the Navy in 1934 and served in HM Ships Challenger Repulse and Victoria and in the Royal Naval Hospitals at Chatham Haslar Plymouth Dighi and Trincomalee. He reached the rank of Surgeon Captain and then retired in 1961 to build a second career with May and Baker Ltd as Senior Medical Advisor He played an invaluable part in the development of that company's medical products until he retired in 1975 His third career was with the Blood Transfusion Service and he was still working on disability pension assessments until shortly before his death at the age of 79

Mark was a man of diverse talents A good linguist he was fluent in Gaelic and Urdu knew Latin Greek and French well translating learned emendation papers from the French for various journals He published many articles in the British medical press but he was especially proud when he completed the History of the Clan Gunn published in 1982 He had a wide-ranging enquiring mind and was particularly pleased to discuss matters of philosophy religion and natural history He relaxed by gardening playing the bagpipes and was an indefatigable walker

Mark married twice first in 1934 to Hilda (Jill) Rowell and after her death in 1951 to Pat Cowan He had five children the eldest two of whom are medical and two grandchildren one of whom is a doctor and one is heading that way

He died peacefully after a short illness on March 7th 1988 in Gloucester Royal Hospital and we extend sympathy to his widow Pat and family

A further appreciation of **Surgeon Captain Rugg Gunn** *has been received from Surgeon Vice Admiral G J Milton Thompson KBE QHP FRCP*

Mark Rugg-Gunn was the medical specialist at Haslar when I first joined the navy It was immediately apparent that he was an officer of professional distinction and indeed one of the few in those days who had an MRCP Serving under him in later years I came greatly to respect his unsurpassed knowledge of clinical medicine and his penetrating analysis of the difficult clinical problem He also was a most entertaining raconteur and a bag piper of no mean repute The night we dined him out of the Service at RNH Stonehouse with Surgeon Captain Murchison delivering the valedictory in Gaelic and Ruggers piping for all he was worth was a memorable ceilidh evening. He will be sadly missed.

Surgeon Captain V O-D Gartside VRD MA MRCS LRCP DPH, DIH RNVR

Vivian Osmond Brook Gartside died in a road accident on November 28th 1987 He was born in 1917 the son of an industrial chemist. Educated at Royds Hall Huddersfield Downing College Cambridge and Leeds he qualified in 1941 and held house appointments at Leeds before joining the RNVR.

He served mainly in the Mediterranean being involved in many of the sideshows of that war as well as on shore in Egypt and latterly in Greece at the time of the Communist rising for his work there the King of Greece personally decorated him with the Medal of Military Merit Many of his exploits were described in his book Nile Additional

We met as former Navy doctors on our resettlement DPH nurses in London After service at Dover he moved to Oxfordshire as deputy County Medical Officer but the routine duties did not appeal and he took up industrial work at the Royal Aero Establishment at Farnborough Always inclined to independence he later moved to a single-handed practice in Brighton and at the same time used his previous local government experience in a part time appointment as

school medical officer. Unfortunately his later years were dogged with increasing ill-health which he bore with great patience supported by the care of his devoted wife Jeanne whom he had met as a nurse in Leeds.

Garside was a committed and most competent doctor. Undoubtedly the war years influenced his attitudes. As soon as possible he rejoined the RNVR, ending his service as Surgeon Captain to the Sussex Division having been awarded the Volunteer Reserve Decoration and Bar and being appointed Honorary Surgeon to H.M. the Queen. He was a quiet, considerate and helpful colleague who made a considerable contribution to health care in Brighton and Hove for more than a quarter of a century. He is survived by his wife and their four children to whom we extend our sympathy.

Commander M. L. Beaumont Royal Navy died at his home in Essex on 10 April 1988.

Surgeon Vice Admiral G. J. Milton Thompson KBE QHP FRCP writes

Pew Beaumont joined my staff as Military Assistant at the end of 1987. He had previously been working in the Directorate of Personnel's area and brought with him an unrivalled experience of central staff personnel work which at once demonstrated his value to the Defence Medical Services Directorate and to me personally. A very experienced passer he quickly assessed the problems that were inherent in the existing structure and began planning that was so necessary if we were to put them right. All those who called at my office during that first term were assured of a welcome and it was quite remarkable how wide was Pew's acquaintance in all three services. His advice was always considered sensible and to the point but it was not until we did a long tour of British Forces Germany together that I got to know him well and began really to appreciate his warm humanity, bluff charm, humour, intolerance of the second rate and dedication to the service. Pew died suddenly while on Easter leave at his much loved Essex home and his many friends in the naval medical service will join me in heartfelt sympathy to his wife Diana and to his family.

Shortly before going to print, the Journal learnt of the sudden death of Surgeon Lieutenant Commander C. R. Ingamells RN whilst serving at sea in HMS Gloucester.

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SERVICE NEWS

ROYAL NAVAL MEDICAL AND DENTAL OFFICERS

HONOURS AND AWARDS

Order of the British Empire
Military Division
Navy
KBE
Surgeon Vice Admiral G J Milton Thompson QHP

Order of the Bath
Military Division
Navy
CB
Surgeon Rear Admiral T R W Hampton QHP

Royal Red Cross
Navy
ARRC
Superintending Nursing Officer
J C Brown QARNNS

PROMOTIONS

To Surgeon Lieutenant Commander (D)
H R Davies, N S Hall

CONSULTANTS SENIOR SPECIALISTS AND SPECIALISTS

As from the date of this Journal professional advancements will be notified us from the date of grading rather than from receipt of payment

CONSULTANTS

Occupational Medicine
Surgeon Commander C W Evans 10/87
Surgeon Commander A E J Hodges 5/87
Acting Surgeon Commander G M F Woodroof 12/87
Acting Surgeon Commander P Litchfield 11/86

Anaesthetics
Surgeon Commander I F Geraghty 9/87
Surgeon Commander A Yates 5/88

Radiology
Surgeon Commander C D Haughton 6/86
Surgeon Commander J J C Hoge 4/88

Senior Specialists

Pathology
Surgeon Lieutenant Commander C M James

Occupational Medicine
Surgeon Lieutenant Commander J R Broome
Surgeon Lieutenant Commander G M Helliwell
Surgeon Lieutenant Commander C E Pugh

Specialists

E.N.T.
Surgeon Lieutenant Commander H J Cox RNR

Medicine
Surgeon Lieutenant J P Miell

Pathology
Surgeon Lieutenant C Pipkin

HIGHER QUALIFICATIONS

Acting Surgeon Commander D C Brown—MFOM
Surgeon Lieutenant Commander
C D Gillen—MRCP (Ireland)
Surgeon Lieutenant Commander
L J Jarvis—FRCP
Surgeon Lieutenant Commander
J R Broome—AFOM & DIH
Surgeon Lieutenant Commander
R J N Garth—FRCS (ENT)

TRANSFER TO FULL CAREER COMMISSION

Acting Surgeon Commanders R H Taylor
P Litchfield A B Baker
Surgeon Lieutenant Commander S D Glover
S J Ryder D N Tulloch J K Campbell
Surgeon Lieutenants N F J Cripps
G E D Howell R P Johnston A G Hillary
M M Furnish F M Kemp K M Cox
Surgeon Lieutenant (D) S J Liggins

NEW ENTRIES

Surgeon Lieutenant (D) A Sweeney
Surgeon Sub Lieutenant (D) T B Elmer
Surgeon Sub Lieutenant D J Birt
Surgeon Sub Lieutenant (Miss) S J Tanser
Surgeon Sub Lieutenant A J Mellar
Surgeon Sub Lieutenant D G S Blair
Surgeon Sub Lieutenant (Miss) V Maitland
Surgeon Sub Lieutenant D P Fadham

PLACED ON EMERGENCY LIST

Surgeon Lieutenant Commander R W J Haddon

RETIREMENTS

Surgeon Captain J B Gornall LVO
Surgeon Captain J A M Wright
Surgeon Commander P J Banfield
Surgeon Lieutenant Commander (D) D Smith

QUEEN ALEXANDRA'S ROYAL NAVAL NURSING SERVICE

PROMOTIONS

To Senior Nursing Officer

Miss M C Farren Mr N J Howes Mr A Lennon
Miss J S R Houghton Mrs L Bryan

NEW ENTRY

Senior Nursing Officer D J Bowering

RETIREMENTS

Chief Nursing Officer Miss E M T McCloskey ARRC
Senior Nursing Officers Miss D M Thrift
Miss P A West Mr S M McArthur
Mr R Parnham Miss S J Fairclough

ROYAL NAVAL RESERVE

PROMOTIONS

To Surgeon Lieutenant Commander

P Meguiry (*Caroline*)
J J Townsend (*Sherwood*)
A R Hamilton (*Cloverhouse*)

To Surgeon Commander (D)

G H Irvine (*Flying Fox*)

NEW ENTRIES

Probationary Surgeon Lieutenants G D Garrod (*Vivid*)
W F A Miles (*Cloverhouse*)
P J Oades (*Cambria*)
J D L Oades (*Graham*)
Probationary Surgeon Sub Lieutenant (D)
Clare M Jones (*President*)

RETIREMENTS

Surgeon Commander (D) R A Peebles RD (*President*)
Surgeon Lieutenant Commander J S Coles (*Collingwood*)
Surgeon Lieutenant Commander (D) C J B Roberts (*President*)
Surgeon Lieutenant Commander A W Jones
Surgeon Lieutenant Commander (D) P M Adamson (*President*)
Surgeon Lieutenant Commander A H Morris (*Sussex*)

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JOURNAL of the ROYAL NAVAL MEDICAL SERVICE

 ISSN 0035 9033

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Notice to Authors

Contributions should be submitted to the Editor Journal of the Royal Naval Medical Service Institute of Naval Medicine Alverstoke, Hants PO12 2DL, who will arrange for any necessary semi ty clearance. The institution of Medical Branch personnel is drawn to the provisions of QRRN Appendix 35 J

Manuscripts should be prepared in the Vancouver style They should be typewritten with double spacing an wide margins and should include title page abstract (of not more than 150 words) introduction methods results discussion and references, each section commencing on a separate page A non-communication length is between 2000 and 3500 words plus essential tables or illustrations

Tables and illustrations should be referred to in the text Tables should be typed in double spacing on separate sheets Figures should be professionally drawn, making due allowance for the appropriate reduction Glossy black and white photographs should be submitted unmounted whenever possible Titles and detailed explanations should be given in the legends which should be typed on a separate sheet.

References should be numbered consecutively in the order in which they are first mentioned in the text At the end of the article the full list of references should give the names and initials of all authors (unless more than six, when only the first three should be given followed by *et al*) The authors' names are followed by the title of the article the title of the journal abbreviated according to the style of *Index Medicus* year of publication volume number and first and last page numbers Titles of books should be followed by the place of publication the publisher and the year of pg.

> Soter NA Wasserman SI Austen KF Cold urticaria release into the circulation of histamine and eosinophil chemotactic factor of anaphylaxis during cold challenge *N Engl J Med* 1976 **294** 687–91
> Osler AG *Complement: mechanisms and functions* Englewood Cliffs Prentice Hall 1976

1 The Vancouver style *J roy nav med Serv* 1979 65 179
2 International Committee of Medical Journal Editors Uniform requirements for manuscripts submitted to biomedical journals *Br Med J* 1982 **284** 1766–70

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2 RN and RNR personnel on the retired list aged 65 years and over and who have subscribed continuously for 30 years or more—£5 00 per annum post free (single copies £2 00)

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Editorial

oon after the Spring issue the Editor was taken
o task by FMO (Reserves) for failing to include
ie Medical Reserves when quoting the number
f uniformed personnel in the Defence Medical
ervices Surgeon Captain Berry was quite
istified as the figures are more substantial than
often appreciated Standing at some 10 000
ley roughly match the Regular echelon Of this
verall figure 6 500 are in the three Voluntary
eserves the rest in the Regular Reserves At
resent the TAVR element considerably
utweighs the contribution from the other two
ervices but this disparity will be reduced if
urrent plans for the RNR are fulfilled

RNR Officers on recall or training have long
een familiar in RN Hospitals Ships and
stablishments Their value has gone much
eeper than the mere provision of leave relief
hey have brought new ideas new approaches
id special skills from their civilian appoint
ents and many have been in a position to set
o training secondments for Regular officers
id ratings Of particular value has been the
heme whereby LMAs are seconded to civi-
an hospitals under RNR Anaesthetists for a
eek of intensive training in intubation and
ntravenous therapy Over 120 have received
is training in the last five years greatly
hancing their potential in Peace and War

Such activities valuable though they have
een to the morale expertise and War readiness
the RN are not the raison d'etre of the Medical
anch of the RNR The RNR Medical Branch
s a unique War Role in manning the Casualty
vacuation Ferries and as far as is possible in an
lassified journal it is described in the article in
is issue Central to the plan is the Medical
Support Assistant (MSA) Young men and
women with no previous nursing experience will
be recruited to this grade at the rate of 80–100 per
year There will be a major training commitment
involving the RN as well as the RNR The first
recruits have already passed through *Raleigh* and
soon they will be seen in RNMSS and on the
wards Readers may well wish to pass on news of
this new RNR opportunity to their friends and
acquaintances

The focus on the War Role mirrors a change
that has taken place in the RN Medical Service
In the immediate post War years the require-
ment to keep personnel in the Royal Navy and
Royal Marines fit and healthy in order to train
for War was recognised as was the need for
medical personnel to develop War related
medical skills. Individuals were however hazy
as to their personal role in limited or total War
For some hospital personnel the emergence of
Surgical Support Teams was a first step in
remedying this defect and since then things
have moved rapidly Now every area of the RN
Medical Service is conscious of its War Role,
presentations have been given and hardly a
meeting or discussion takes place without it
being raised

This is the final issue under the Editorship of
the present Dean and he wishes his successor
well He thanks the Editorial Committee and
Specialist Referees for their considerable efforts
and apologises to those authors whose articles,
usually on account of length he was unable to
print He is pleased to report that the Editorial
Secretary has almost recovered from her serious
injuries and thanks the Acting Editorial Secre-
tary for so capably filling the gap

Frontispiece

HMS *Curron* River Class Fleet Minesweeper MCM 10 tender to Severn Division RNR

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The Royal Naval Reserve Medical Branch—past and future

J A Malcolm-Smith RD

THE Royal Naval Reserve is an active organisation of paid volunteers who undergo peacetime training to act in a war role in the event of a national conflict. In its present form the RNR dates from 1958 when it amalgamated with the old RNVR which itself started at the time of maritime rearming and reassessment in 1903. The Medical Branch is only a relatively small portion of a much larger whole. Mine countermeasures and all that that entails is the seagoing task of the RNR and in the lay mind is synonymous with its activities. In fact most young men who join the RNR "off the street" intend to become seamen or go to sea in one branch or other. This view as will become obvious later has a certain relevance for the Medical Branch. Those with the academic qualifications and other qualities to become potential officers enter either the Seaman or Naval Control of Shipping (NCS) specialisations. The NCS Branch unique to the RNR, concerns itself with convoy formation and management and is associated both with the Maritime Headquarters Units (MHQ) and the Sea Training Centres. The Communications Training Centres train RNR and WRNR officers and ratings for both sea-going and non sea going communications roles and are situated in many cases far distant from the coast exhibiting a Naval presence away from traditional port areas. Twenty nine RNR Training Establishments exist in the UK and one in Gibraltar all of them require medical support which is in part the role of the Medical Branch of the RNR.

Surgeon Commander Malcolm Smith RD RNR is Medical Officer Training (Reserves) and a Consultant Anaesthetist at the Royal Infirmary, Edinburgh.

The Medical Branch of the RNR 1956–1988

Medical Officers in the immediate post war years were drawn almost entirely from the ranks of former war service or National Service officers. National Service was discontinued in 1960 and although there are a number of ex-RN Short Service Commission officers the majority of doctors in the RNR have joined without any previous Naval experience. The reasons for joining are ill defined to add a new dimension to professional work to satisfy a certain yearning for adventure and activity and to contribute something to the nation's defence all figure. At the time of writing there are 186 Medical Officers in the RNR represented by both GPs and the whole spectrum of the specialities (*Table 1*).

Table 1 RNR Medical Officers under Specialities

General Practice	43
Medical Specialities	24
Surgical Specialities	29
Anaesthetics	23
Accident and Emergency	8
Radiology	5
Occupational Medicine	8
Others	43

Nursing Officers were introduced as direct entry QARNNS(R) Officers in the 1970's. Until

recently their numbers have been limited to approximately two per Division but, as will be explained later they are on the increase. The rank of Surgeon Sub Lieutenant was introduced in the late 1960's in parallel with the similar rank in the Royal Navy to give clinical phase medical students a chance to participate in the Medical Branch. Personal experience has shown the extraordinary benefit to the Service of enlisting Medical Officers at an early stage of their careers.

The rating structure of the Medical Branch of the RNR was until recently entirely comparable with that in the RN and this arrangement presented no problem when ex war service and National Service trained personnel came forward. However the task of training ratings to RN Medical Assistant standard from scratch was formidable and whilst some were sufficiently enthusiastic and dedicated it meant that the numbers achieving MA rate from no previous experience remained small. Various syllabi were introduced to attempt to rectify this problem and in particular a rate of MA(R) was introduced where the whole extent of MA training was not required. Medical Technicians in the form of trained nurses were introduced but this led to problems as their RNR senior rate status was commensurate with their professional training but not with their Naval experience. Many were enthusiastic and made up for their relative over rank by undertaking training with other Branches but eventually recruitment of Medical Technicians was discontinued.

The Role of the RNR Medical Branch

The peacetime role of any Armed Service is to prepare for the war situation and in this respect the Reserves are no different from the RN. This war role will be discussed later but a large part of the peacetime role is of course looking after the health and fitness of ships' companies. Every officer and rating on Lists 3 and 4 of the RNR is expected to attend the parent Division once or twice a week for two hours. The 'Drill Night' activities are (a) medical examinations, and (b) training of ratings.

Medical examinations are mainly for new entries into the RNR and are conducted along the same lines as those for the RN as the standards are the same. Facilities are not available for specialist examinations and if these are necessary the candidate is referred to a nearby RN Recruiting Office, Naval Establishment or RAMC Unit. Sea Training Centres train divers and the clinical part of the examination is usually performed at the RNR Division by a Medical Officer who has undergone the INM course for Diving Medical Officer. There is also the continuing task (as at RN Ships and Establishments) of updating PULHEEMS records of serving officers and ratings. In conjunction with the medical examinations goes documentation and as in the RN considerable time and effort goes into this unglamorous but totally necessary aspect of Service Pay life.

Training of ratings has hitherto been rather the Cinderella of Medical Department activities but in the last year a quiet revolution has been taking place. A new syllabus has been produced for ratings which is manageable in content and detail. More important perhaps officers and senior rates are required to go on Instructional Techniques courses to be able to teach the syllabus. Ratings undertake the course to be designated as Medical Support Assistant (MSA) and will be trained over three years in First Aid, basic nursing skills and Sick Bay administration. Their promotion structure will eventually be parallel to RNR MAs but, unlike MAs their training will not fit them for independent medical care of personnel but rather enable them to work under Nursing Officer and senior rates in a hospital environment. Training started in April 1988 in those RNR Divisions where sufficient trainers were available. The conduct of the course is supervised by an RN Chief Petty Officer whose sole task is travelling to RNR Establishments to assess progress and to advise on setting up training courses.

Whilst the training of medical ratings on a large scale is a new concept the training of all ships' companies in First Aid is well established as a part of Medical Department responsibility. The larger Divisions have sufficient personnel amongst medical and nursing staff to provide their own group of instructors, others make arrangements for visiting RN teams to undertake instruction. The enthusiasm of RNR officers and ratings for First Aid is variable as there are so many competing requirements for sea going personnel and limited time in which to undertake training. However the rule of ten per cent of ship's company being trained in First Aid stands and the numbers are being maintained.

Continuous Training and War Role

The broad outline of the role of the RNR is to

support the Royal Navy in time of war but as far as the Medical Branch has been concerned the details of this have changed over the years Until the 1970 s it was envisaged that in time of threatened or actual conflict each officer and rating would be drafted to a ship or establishment where his or her skills could be appropriately employed In effect it would have meant large numbers arriving at one of the UK hospitals and being sent on or kept as the situation demanded This rather ponderous arrangement was in part dictated by the requirement for recall of officers to be made by Royal Proclamation This in effect meant that Parliament had to pass the order for recall and a national emergency could be well developed before this would take place The system was changed on 18 May 1962 when call out by the Secretary of State for Defence could be made at any time when warlike operations are in preparation or in progress It was appreciated during the Falklands Campaign that Reservists of all branches might be required for recall at short notice Many Medical Officers of the RNR did in fact volunteer for recall at the very beginning of the South Atlantic conflict and contributed by filling billets at Haslar and elsewhere left by those RN Medical Officers who had sailed to the South Atlantic The RNR Medical Branch is proud to have been the only branch of the RNR to have been able to contribute directly at that time

At about that time the idea of having dormant war appointments for each officer was mulled that is to say each Medical and Nursing Officer would know to which ship hospital or establishment to report if an order or recall came This scheme has now been superseded in part because of an altered war role of the RN Medical Service as a whole

Every officer and rating as part of the commitment to the RNR is required to spend fourteen days per year in continuous training Ratings under training require to attend courses at the Royal Naval Medical Staff School at Haslar and when they have reached their appropriate rate may then attend a suitable ship or establishment. Up until 1987 the choice of training location for Medical and Nursing Officers and trained ratings was left more or less to the individual though naturally some courses such as the New Entry Courses for officers and ratings were mandatory In the broadest sense this was indeed offering support to the RN in that RNR personnel could fill slots and allow the permanent Service to take leave

Many RNR Medical Officers returned year after year to the same Departments some worked out routines for attending different places The whole system had become quite organised with CINCNAVHOME's Medical Department issuing a monthly list of vacancies for training or recall There is no doubt that this arrangement for training was generally acceptable to the RN Medical Branch and to the majority of the RNR Medical Officers it led to informal exchanges of ideas on all sides, it kept RNR medical and nursing personnel abreast of developments in the Royal Navy it allowed them variety in training which was essential when their war role was more or less undefined and it allowed a sense of commradeship between the RN and RNR Medical Branches to flourish However it was essentially a training role to support the RN in peacetime whereas the objective is to supply a role for the RNR in time of war

The New War Role for the RNR

From this useful but rather indefinite role there has now been conceived a change which will allocate to the RNR a specific war task rather than have its members diffusely absorbed into the areas of activity of the Regular Service The task in question is the medical manning of the sea borne segment of the Casualty Evacuation Chain In fulfilling this role the RNR Medical Branch will link in with its counterparts in the TAVR This key commitment will alter the RNR Medical Branch from being a relatively small section of the Reserves as a whole into being a major element The change has started to take place already with the introduction of the MSA rating who can realistically be trained from a position of no prior medical knowledge at the RNR Divisions (of which there are twenty nine) on Drill Nights Naval Nurses are being actively sought as their particular value is that they are professionally trained and only require Naval orientation and experience at working in a different environment Above all however the change has to be one of change of attitude to the RNR whereas previously the popular image both to the public and in all the Services was that the RNR was mainly concerned with mine countermeasures it will now have another major role as a medical organisation Commanding Officers of RNR Divisions are becoming aware of this and recruitment of MSA ratings and Naval Nurses will have to be a priority

The next stage following recruitment and branch professional training will be to acquaint personnel with the conditions under which they will require to work. For this one is particularly indebted to the Royal Army Medical Corps for offering all the facilities at their Territorial Army Training Centre in Cheshire. This Inter Service help and co operation is heartening as there is no doubt that the TA has over the years gained a wealth of experience in this kind of activity. It is anticipated that much of the future training will in fact take place in conjunction with the TA.

These then are the plans and hopes for the future and one year on it is useful to look at progress. At the time of writing the strength of the Medical Branch stands thus (*Table 2*)

Whilst the number of ratings will grow in the years to come the complement of Medical Officers will change in character rather than numerically (at present over a quarter of the MOs are above the age to be expected to go to sea in adverse conditions!) There will be more than enough places for all to contribute and serve in the new look RNR Medical Branch.

Table 2 Strength of RNR Medical Branch

Medical Officers (all specialities)	186
Nursing Officers	49
Medical Assistants	41 (13 Sen or Rates)
Naval Nurses	42
Medical Support Assistants	133 (all under training)

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'My Story'—Sinking of HMS *Gurkha* January 17 1942

An extract from the Memoirs of Dr W M Brown MD DPH FFARCS

Surgeon Lieutenant W M Brown RNVR has been reported as wounded—Service News Journal of the Royal Naval Medical Service Spring 1942

That evening after dinner as was the custom we spread ourselves round the wardroom either reading or snoozing or just talking. Inevitably two or three officers would start on some topic anything from philosophy to prostitutes, and before long there would be a free debate in which the whole wardroom took part.

I went to my bunk shortly before midnight. I had one of four cabins about seven feet square which were beside the wardroom. The wardroom occupied the whole width of the ship and with the pantry made up a water-tight compartment. The four cabins two on the port side and two on the starboard side, with a wide passage or cabin flat in the middle between the cabins was also a water tight compartment. To get from the wardroom to the cabin flat one climbed a ladder out of the wardroom through a man-hole onto the main deck then along the deck a few yards to another man-hole and down a ladder which led to the cabin flat. This arrangement of water tight compartments localised damage to the ship. It took me seconds to undress as I had only to remove my jacket and shoes leaving on trousers and a choker pullover and I was ready for bed.

I was awakened by the loudest explosion I have ever heard and thrown out of my bunk. I landed on my feet facing the curtain door of the cabin and was very wide awake. The door-way of the cabin was criss-crossed with burning planks which I could make out through the sheet of flame which filled the door way. This is it flashed through my mind and without stopping to think for a moment proceeded to lift the burning planks away in order to get into the cabin flat. My action was purely automatic and actuated by an irresistible urge to escape from the tiny blazing cabin. I never knew the real meaning of the phrase 'irresistible urge' before. As I grasped the planks I could feel the heat of the flames in my face and hear the sizzling of the burning flesh of my hands though I was not conscious of any great pain. The planks were removed surprisingly easily—they had just been stuck to the varnished door way by the heat—and I was out in the cabin flat. The flames rapidly died down and in the ensuing darkness I could not find the ladder which would take me up through the man-hole on to the weather deck and safety. In the darkness I moved about groping for the ladder. When I had crossed the few square yards where it should have been several times I realised with a sinking feeling that it had disappeared. The only means of escape had gone and I was trapped in a water tight compartment. I groped my way round the other three cabins calling their occupants but nobody answered. Never did I feel so lonely. I could hear the hiss and crackling of a terrific fire uninterrupted every now and then by the explosion of small arms ammunition. The anti aircraft Pom Poms situated high up on the after superstructure were exploding erratically so probably the flames had reached that height. The fire was in the ward

Dr Brown is now retired from his post as Senior Anaesthetist at the Royal Victoria Hospital, Belfast.

room just on the other side of the bulkhead from the cabin flat. Beneath me were the fuel oil tanks and beneath the wardroom depth charges and four inch shells were stored. Good God. Would the heat of the fire ignite the oil tanks or set off the ammunition and blow the ship to pieces? And I was trapped in a metal box. I could do nothing but wait and pray that if the ship did not blow up and the fire was put out I would be found.

Suddenly a loud clanging noise startled me. It came from beneath my feet. I soon recognised it as the engines trying to turn the propellors but the propellor shaft was loose in its seating and, after a crescendo of clanging metal during which I was afraid the whole propellor shaft was going to come hurtling up through the deck I was standing on the engines stopped and all was quiet again.

I called for help but as I could hear no voices I presumed everyone was out of earshot. In any case no-one could get to the cabin flat because of the fire. Then I heard a voice, the thin piping voice of the midshipman. It came from the wardroom on the other side of that bulkhead which was keeping the fire from me. How could he be alive in that inferno? He was shouting. Guns lights. (He wanted the commissioned gunner to get the electric lights working again). He called three times. In the middle of the third call there was the sound of a heavy object falling and the call was cut short. I felt more lonely than ever. The thought that I might not be rescued hit me. The fear that the ship might blow up at any moment and the frustration of not being able to do anything about it was almost unbearable. I felt like a dog that is cold and miserable standing on the doorstep on a wet winter's night, gazing at the door which he hopes will magically open for him but which he knows in his heart will not.

I was aware now that there was a gentle roll of the ship and that, as it moved from side to side water was swirling round my ankles. I had no idea where this water was coming from but its presence left me with the one thought, the ship is sinking. By now I could vaguely make out the outlines of the cabin flat and presumed it was daylight outside. I had no idea of the passage of time. It was all so interminably long. Now, when I touched the metal bulkheads in my half-blind groping in search of the ladder I got what seemed like a mild electric shock in my fingers. I could not understand this until I felt something hanging from the end of my fingers. I tried to pull this away - too late to realise it was the burnt skin of my own hand which had folded outside in like a glove and was anchored at the nail bed. Now I knew that even if I did find that ladder and could reach the man hole I could not undo the strong clasps which held it in place. The water was now up to my knees.

Suddenly the cabin flat was ablaze with light. A sheet of flame spread across the water and set me alight. Automatically I splashed the water I was standing in up over my head and as quickly as it came the flame disappeared. A film of oil on the water had been ignited by the heat of the bulkhead next to the wardroom. Inexorably the water rose and my hopes of escape sank. Now I could no longer make out the outlines of the cabin flat. The fire had blinded me! When the water reached my waist and I was still standing helpless and blind I felt a sudden surge of heat and realized that I had again been set on fire. Splashing the water up round myself again soon extinguished the flames.

I could feel the water slowly rising up my body. I calculated I had about fifteen more minutes of life left. When it reached shoulder height I began to have a most irrational, but none the less real fear that the ship would sink while I was still alive, but trapped inside it. To be drowned in the cabin flat with the ship still afloat seemed a much less horrible alternative. So strong was this feeling that I began devising means of ensuring that I would not be taken down with the ship alive. There was a rack of revolvers in a case on the bulkhead between the two port cabins, but by the time I thought of them as a means of escape they were already under water. In any case my hands were now sore and would have been incapable of handling a revolver. When the water reached my neck I was swept off my feet with the gentle roll of the ship. This really seemed the end and I yielded again to the lure of self-destruction. The thought of drowning myself occurred to me but even at that moment of deep despair the instinct of self preservation proved too strong and the mood passed so that I only got as far as dipping my face in the water once. I was now afloat in the water which, with the roll of the ship, swished from side to side carrying me with it. I could still see nothing but imagined all the debris of burnt planks cigarette ends, oil and filth which floated around me. Never did I feel so desolate. Who knew or cared I had three to four minutes left to live? Perhaps I would be knocked unconscious as I floated past some metallic projection. So only minutes were left.

The very fact that there was now no possible alternative, no wondering about escape no train of hoping for a miracle to happen left me wonderfully and illogically calm I thought of the people who would miss me—the ones who would really grieve for me I was very humbled to discover how very few there were My mother my fiancée my best friend Charles

How long now? I automatically looked up to see how close my head was to the upper bulkhead I could not believe it! I could see and what I saw was a tiny triangle of daylight about ten feet above my head I immediately swam over to it, hope triumphing over reason When I got there I found a space where solid deck should be Using my elbows (I could touch nothing with my hands) I climbed up through what could only have been the main weather deck of the ship split wide open by the explosion I found myself in a small arms ammunition store which I recognised having been in once before A case of small arms ammunition had exploded against the bulkhead and blown a hole in it I looked at the jagged edge of the metal and shuddered as I thought of touching it with my hands The hole now that I was looking at it on the level was bigger but it looked far too small to crawl through I knew that if I got stuck or my jersey caught on those jagged edges I could never free myself and would be left half in freedom and half in prison squeezing myself into the slimmest possible shape I put my head and shoulders through and found to my relief that not only did my jersey not catch but that I was able to lean my elbows on the torpedo tubes out on the open deck to enable the rest of me to wriggle through I was free out in the open in the clear fresh air and daylight The contrast was unbelievable Despair was replaced by hope darkness by light and the nauseating smell of crude oil burning clothes hair and flesh by the smell of the sweet pure air I took in great lungfulls of it as though I had never experienced the sensation before I was sprawled across the torpedo tubes about four feet above the main deck Not having the use of my hands I wriggled down off the torpedo tubes but as my feet touched the deck I realised my jersey had caught on a projection on the torpedo tube and I hung half suspended and powerless to do anything about it The main deck (my former ceiling) I saw was now awash and the ship was badly down by the stern I saw sailors up forward and rejoiced that the ship had not been abandoned My blindness in the cabin flat had obviously been due to the oil in my eyes and not burns

Then a hand shot out from nowhere and unhooked my jersey What with the suddenness of the action my oil covered feet and a roll of the ship which sent a wave over the deck I fell and slithered down the sloping deck into the scuppers Luckily the guard rail prevented me from going overboard But now willing hands were helping me, but after walking a few yards my legs gave up and I sank down gratefully on the deck

We were picked up by a Dutch destroyer It was crammed with survivors from the Gurkha. (Unfortunately most of the officers were having breakfast when the torpedo struck the ward room Only the Captain Guns' and a Sub Lieutenant who were on duty on the bridge at the time survived) At last I got lying down and glorious relief an injection of morphia. Never did I revel so luxuriously in the enveloping arms of morphens The thought of the U Boats still being about crossed my mind but the injection eased my fears as well as my pain and I was soon asleep

J roy nav med Serv 1988 **74** 141–146

Microbial Identification by Gas Chromatography

M A White, M D Simmons, A Bishop & H A Chandler

Abstract

Gas chromatography is rapidly being accepted as a valuable technique for the identification of microorganisms as the speed of identification can be significantly greater than current biochemical techniques. The Health Department of the Institute of Naval Medicine has recently installed a fully automated gas chromatograph dedicated to rapid bacterial analysis particularly in the area of clinical microbiology. This paper describes the preparative and analytical methods employed by the system and the results of preliminary studies.

INTRODUCTION

EARLY bacterial identification involved purely objective methods for characterisation and relied heavily on personal judgement and experience. This arose because of the limited number of reliable methods capable of the complicated analyses necessary for identification. It is now recognised however that accurate identification can only be achieved with objective analytical techniques.[1] Bacterial identification by chemical analysis can be approached in two ways either by analysis of the end products of metabolism or analysis of bacterial components such as lipids or proteins.[1] With the development of bonded capillary columns gas chromatography has become a valuable technique for rapid bacterial identification.[2-4] The advantage of gas chromatography over biochemical techniques is the speed with which analyses can be performed and microorganisms identified. Gas chromatographic identification is achieved by determining the fatty acid composition of bacterial cell lipids. Individual species have distinct fatty acid profiles although bacteria will alter their lipid composition in response to environmental changes. Alterations in culture conditions will produce variable fatty acid profiles.[5,6] Consequently in order to obtain reproducible results strict culture and extraction conditions must be adhered to. Bacterial species are distinguished both qualitatively (by the presence or absence of particular fatty acids) and by differences in the abundance of each fatty acid present.

This paper reports our preliminary assessment of the Hewlett Packard Microbial Identification System for the identification of gram-negative bacterial isolates from clinical sources.

METHODOLOGY

Sample preparation

Cells from a primary isolation plate are transferred to a culture plate of trypticase broth soy agar (Difco) and incubated for 24 hrs at 28°C. Cells for analysis are transferred to a screw cap test tube for extraction. Four steps are involved in sample processing.

1 *Saponification* Free fatty acids are released by adding 1 ml of 3·8 M NaOH in 50% methanol and heating at 100°C for 30 mins.

2 *Methylation* The free fatty acids are insufficiently volatile for rapid analysis by GC. They are converted to fatty acid methyl esters to speed up analysis. Methylation is achieved by adding 2 ml of 6 M HCl/methanol 1·1 v/v

Surgeon Commander Simmons Consultant in Pathology RNH Haslar. Surgeon Commander Chandler Consultant in Pathology RNH Plymouth. Dr M A White and Mr A B Shopland in the Health Division at the Institute of Naval Medicine—Alverstoke

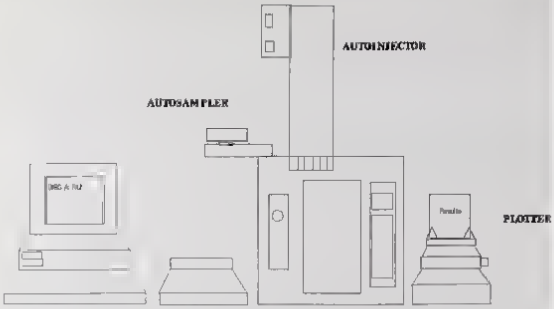


Fig 1 Schematic diagram of the Microbial Identification System showing the principal components

Table 1 Results of analyses of several clinically significant bacterial species by the Microbial Identification System. Results are expressed as a % of correct identification as described in the text

Bacterial species	% complete id	% incomplete id	% incorrect id
Pseudomonas aeruginosa	100		
Ps Putida	64	36	
Proteus Mirabilis	100		
Escherichia Coli	9	40	51
Shigella Sp	67	13	20
Klebsiella Sp	30		70
Enterobacter Sp		80	20
Bacillus Sp	100		

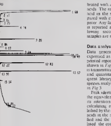
3 *Extraction* The fatty acid methyl esters are extracted into 1 ml of hexane/diethyl ether 1 : 1 v/v. The aqueous phase is discarded.

4 *Washing* The extract is washed with 3 ml of 0·3 M NaOH to remove contaminants.

Chromatography

The gas chromatographic system is shown in *Fig 1*. Separation is performed on a narrow bore capillary column which offers the necessary chromatographic properties[7,8]. The detection system is flame ionisation detection. The paramatics of the system are set by the operator. Hydrogen is employed as the carrier gas. All other chromatographic conditions are set by the computer and cannot be altered during an analytical run. The automatic sampler and the 100 place sample tray allow complete automation of sampling and injection. Samples are simply loaded onto the tray and the sequence entered into a table in the computer.

On starting an analysis the system is cali



RUN # 29
WORKFILE ID C
WORKFILE NAME
SAMPLE # 2

AREA%

RT	AREA	TYPE	AR/HT	AREA%
1 60	3 2278E+07 TSBB		0 064	99 566
2 18	209	DBBB	0 062	6 4479E-04
3 16	288	D BB	0 024	0 6383E 04
3 75	769	VV	0 038	0 002
4 74	4096	PB	0 031	0 013
7 28	9651	BP	0 040	0 030
8 86	623	BB	0 053	0 002
8 8	1619	VB	0 044	0 005
9 64	7453	VB	0 043	0 02
10 19	20753	BB	0 043	0 064
10 49	37167	PB	0 043	0 115
12 05	13925	PB	0 045	0 043
12 22	654	PP	0 045	0 002
13 6	27792	VB	0 046	0 086
13 98	546	BB	0 059	0 002
15 56	1894	BP	0 048	0 003
15 69	2915	VV	0 300	0 009
20 33	6493	VV	0 28-	0 020

Fig 2 A typical chromatogram plotted by the integrator following injection of a sample into the gas chromatograph The retention time for each fatty acid peak is printed beside the peak Retention times and % area of peaks are printed sequentially at the end of the chromatogram

brated with a known standard mixture of fatty acids The retention time and amount of each acid in the standard is determined and compared with expected values stored in the computer Any failure to match the expected values is reported and the calibration repeated Following successful calibration the unknown samples are sequentially analysed

Data analysis

Data generated from the analytical run is expressed as raw chromatographic data and a printed report The chromatogram produced is shown in *Fig 2* The raw chromatographic data is transmitted to the computer for identification and quantitation of each peak, and a subsequent library search to identify the bacterial species analysed The report produced is shown in *Fig 3*

Peak identification is achieved by calculating the equivalent chain length for each peak from its retention time The reference system for calculating equivalent chain lengths is established by the calibration mixture Once the fatty acids in the unknown sample have been identified and the relative quantities of each calculated the composition is compared with reference compositions of known organisms stored in the library The reference library has been compiled by the manufacturer by analysing known organisms many times and producing a mean composition The computer uses complex statistical analysis to match unknown samples with reference organisms The closeness of match is expressed by a numerical value termed the similarity index This value is printed beside each match made by the computer If a search produces only one match with a similarity index greater than 0 5 it is most likely that the identification is correct However with some groups of bacteria a library search may produce more than one match In this case matches are printed in descending order of similarity Additional biochemical tests may then be necessary to differentiate the matches

RESULTS AND DISCUSSION

Bacteria obtained from clinical samples isolated in RNH Haslar were initially identified by reference methods using the API 20E identification system For evaluation of the Microbial Identification System the same bacterial isolates were treated as described in the methods section and the results compared with those of the API system

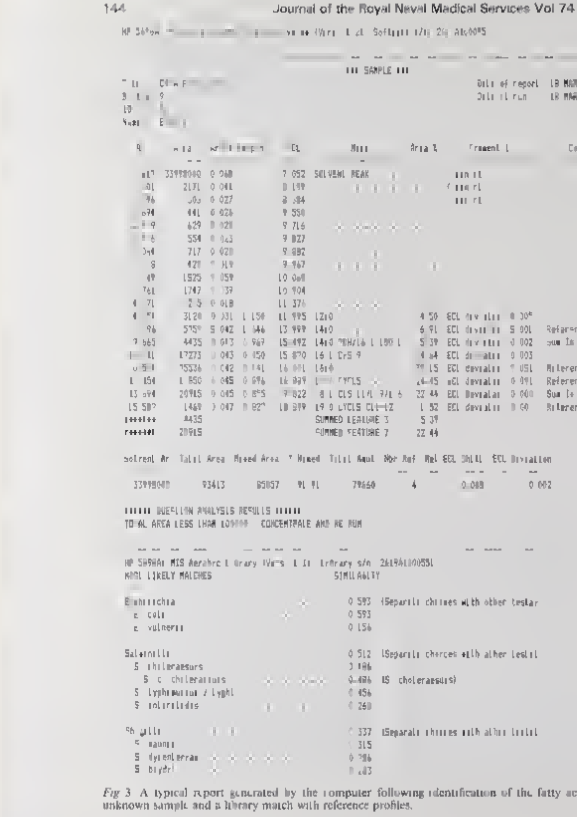
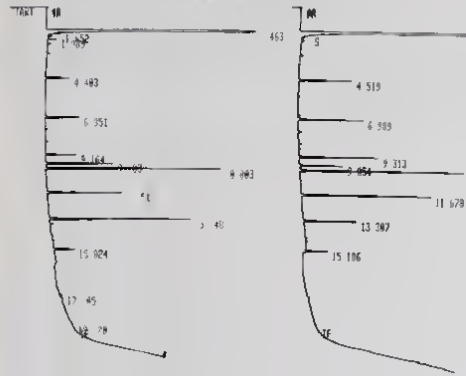


Fig 3 A typical report generated by the computer following identification of the fatty acid peaks in the unknown sample and a library match with reference profiles.



4a.

Retention time	Fatty acid
4.403	C12:0
8.851	C14:0
9.184	C14 0 3OH
9.703	C16:1
10.003	C16:0
11.519	C17:0 CYCLO
13.148	C18:1
15.024	C19:0 CYCLO

4b.

Retention time	Fatty acid
4.519	C12:0
8.989	C14:0
9.313	C14.0 3OH
9.854	C18:1
10.155	C16;0
11.878	C17:0 CYCLO
13.307	C18:1
15.188	C19:0 CYCLO

Figs 4a & 4b 4a Chromatogram of an extract from *E Coli* correctly identified by the system 4b Chromatogram of an extract from *E Coli* incorrectly identified by the system The identity of each peak is written beside the list of peak retention times.

Complete identification by the MIS system was assumed when the organism printed at the top of the list of most likely matches was the same as that identified by the API method If the organism appeared further down the list of matches the identification was assessed as incomplete Identification was incorrect when the organism did not appear on the list of matches The results of analyses of several different bacterial species are shown in *Table* I

The results show that a number of clinically significant organisms including some enterobacteriaceae are well identified However the more common enterobacteriaceae species are poorly identified or misidentified *Figures* 4a and 4b show the chromatograms for correctly and incorrectly identified *Escherichia Coli* isolates The differences in the two traces are small but obviously significant for correct identification Further examination of all the chromatograms from *E Coli* samples analysed reveals that misidentification occurs when the levels of cyclic fatty acids C 17 0 and C 19 0 exceed 15% and 5% respectively Under normal culture

conditions for *E Coli* cyclatin acids are minor lipid components However large numbers of *E Coli* isolates analysed by the MIS system show considerable variability in the ratio of these two fatty acids and also C16 1 and C18 1 unsaturated fatty acids In the majority of misidentifications the isolate is identified as *Shigella Sp* rather than *E Coli* as this organism has significant amounts of the cyclic fatty acids

It is apparent therefore that when enterobacteriaceae species are cultured under the present MIS conditions they can produce remarkably similar fatty acid profiles which frequently leads to misidentification The present system was developed primarily for identification of plant pathogens and the culture conditions are optimised for these organisms Such conditions are not suited to human pathogenic species In addition the numbers of organisms analysed in producing the reference profiles for the MIS library appear to be significantly fewer than for other identification systems and this may also influence the degree of misidentification

We are currently awaiting delivery of software which will enable us to generate our own library reference profiles This will initially allow us to considerably expand the number of reference strain analyses thereby producing more accurate mean reference profiles which will allow for the obvious variation one observes in extracts from the same species of organism Subsequently alternative culture conditions can be chosen which may produce sufficient variation in the fatty acid composition between the enterobacteriaceae to differentiate them and achieve more accurate identification

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Do We Survive with Survival Suits?

Rolf Herrmann

Abstract

The availability of immersion suits on board merchant ships is recommended in *1983 Amendments to the international convention for the safety of life at sea 1974 (IMO)*. Suits approved by the Federal German Republic were tested in a wave tank using an immersible dummy. Extra buoyancy in the head region was required to correct the horizontal floating position. Buoyancy from a life-jacket was preferred to other sources. At 1 m wave height flooding time of the face varied from 0.3% for one suit to 100% for another. Suits lined with non-absorbent material gave the best results.

INTRODUCTION

Despite improvements in ship design and construction and in addition to the use of modern technical aids to navigation ships continue to collide, run aground or founder with consequential loss of life. It is some consolation to know that the death toll has been lowered in recent years by the introduction of more efficient life-jackets, survival suits and the development of better life-boats and rafts.

In recent times it has been accepted that deaths at sea formerly classified as accidents caused by drowning may have had as a primary cause either fatigue and/or hypothermia. It was the research of Macintosh and Pask[1] in relating the construction of lifejackets to the stable buoyant position of the human body in water that brought about world wide improvements in design and construction of life jackets. These more efficient types can keep an exhausted or hypothermic casualty in such an advantageous position in the water that he can be drowned only under extremely bad weather conditions.

Unfortunately death is frequently still caused by hypothermia in temperate and cold latitudes. The prevention of hypothermia was thus an essential step which was taken by the International Maritime Organization (IMO) with the *1983 Amendments to the International convention for the safety of life at sea 1974*.[2] As a result immersion suits with or without insulation to protect shipwrecked persons against hypothermia have been introduced by mandate in various shipping countries. In the Federal Republic of Germany immersion suits with thermal insulation only are allowed. It is very important, indeed to determine the efficiency of these survival suits and to find answers to the following two questions: How do they protect and what can be improved?

The Department of Nautical Medicine in 1985 tested survival suits for their quality of thermal insulation.[3] In the course of 1986 we dealt with some supplementary but most important details. The German national and international regulations provide for tests of life jackets and immersion suits only in smooth water. In case of shipwreck the sea is however often very rough and it has to be proved that the survival suits are also really efficient in rough seas. Some years ago our tests with life jackets in waves[4] showed significant differences in the quality of the various models but also indicated the possibility of improvements. Similar tests were recently performed with immersion suits.

TEST METHODS AND CONDITIONS

The tests were performed in a wave tank of the German Federal Navy. In this tank waves of 1

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m height can be produced which have a higher slope steepness than natural sea waves A reverse wave produces this steepness and by this characteristic waves much higher than natural ones are simulated

We used an immersible dummy as developed by Pask[3] of which the weight size and specific gravity as well as the distribution of buoyancy are equivalent to an average full-grown man The dummy was fixed in the wave tank by means of long buoyant cords thus providing an identical position of the dummy for all the suits to be tested The prime objective was to measure the time that the nose and mouth were under water A measuring device was chosen which in response to flooding produced radio signals that were sent to a receiver via a multi channel bio telemetric device The data was registered by a printer for later analysis in the laboratory

Additional tests were performed with volun teers however without objective measure-ments These tests should verify the reliability of the findings with the dummy

The tests were performed over 14 days with a total number of eight immersion suits and 11 life-jackets (of different models) with or with out splash screens All were tested in different combinations for about 10 minutes after a stable position in the water had been reached The total number of combinations was 69 All immersion suits tested correspond with the IMO standards All models of life-jackets tested are used in merchant and navy fleets and on pleasure boats

The suits had to withstand more unfavour able conditions than those applied during the official approval test During one test series with volunteers it was evident that at fairly regular intervals varying quantities of water got into the suits None was really watertight at the face of the zip fastener It has to be added that the international rules foresee in an emergency the need to put on the suit in wet condition ie to don it in the water Consequently a longer stay in the water involving the penetration of water into the suits had to be simulated

The tests of the different suits showed widely varied results (*Fig 1*) The best result achieved over the whole time of exposure was 0 3% the most unfavourable 100% which means that the nose and mouth of the person wearing suit No 2 were splashed less than 1% of the time of exposure whereas those of the person with suit No 8 were continuously flooded We had to stop the dummy test with suit No 8 because the measuring device was practically immersed all the time thus endangering the technical equip-ment

The most important findings are listed below

Suit number	*% of flooding time of face (mouth and/or nose)*
1	0 8
2	0 3
3	39 0
4	54 8
5	64 0
6	27 9
7	7 0
8	100 0

The suits Nos 1 2 6 and 7 had been equipped by the manufacturer with additional buoyant material with foam on the inside of the hood and/or in the form of inflatable buoyant components fixed on the outside of the suit This feature gave less flooding of the nose and mouth The remaining suit models were not provided with supplemeotary buoyancy

Further differences were obvious The suit models Nos 1 to 7 with the exception of No 2 were made from Neoprene or similar material. Suits Nos 2 and 8 had the same construction, they were manufactured from waterproof cloth with a lining on the inside These linings differed in that No 2 had a lining which did not absorb water whereas that of No 8 readily absorbed water which penetrated the suit In dry conditions the effective buoyancy of both suits was identical but when large quantities of water got into the suits No 2 retained its relatively high buoyancy in contrast No 8 became like a piece of waterlogged wood barely floating in the water Every wave would splash the wearer without lifting him

Supporting attachments (*Fig 2*) may not be absolutely successful Previous tests with life jackets equipped with splash screens showed significant reductions of the flooding frequency and time One of the tested suits was equipped with a splash screen The flooding time showed a value of 54 8% without and 48 8% with the use of the screen The difference was only 6 1% The modest splash protection may be explain able by the low position of the head in the water The nose and mouth were not predomi nantly splashed by water from above but rather they were flooded by the deep immersion of the head in the water This cannot be prevented by the use of a splash screen When the same suit model was worn together with a life jacket of 10

up buoyancy according to the SOLAS regulations from 1974 the flooding time was lowered to 5 6% which represented a reduction of 18 9% In this test the use of a splash screen involved a further reduction by 4 1% to a final value of 1 5% The best cold and flooding protection could clearly increase the chance of survival Nevertheless this suit model equipped with the described supplementary attachments could not reach the most favourable values of suit No 2 when not equipped with life-jacket and splash screen. The only purpose of these additional test results was to demonstrate which constructional improvements were essential in order to achieve test results similar to those of the more efficient suits.

Fig 1 Comparison of suits

The tests which are described in the following do not correspond with the basic flooding times of the preceding ones because temporarily another position of the dummy was chosen in the water The suits were given new numbers (*Fig* 3)

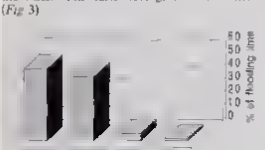

Fig 2 Supporting attachments

Additional inflatable parts affixed to some of the suit models considerably improved the test results They however did not come up to the results when using life-jackets The results according to *Fig* 3 demonstrate the effect of attached and/or added buoyant parts Both suits A and B were made from Neoprene The first suit A had no additional buoyancy The flooding time could be lowered by 50% by the use of an inflatable buoy belonging to the suit (A 1) The result could be improved considerably when using an approved life jacket instead of the inflatable buoy (A 2) The same suit model with altered constructional criteria was tested according to column A 3 Additional buoyancy was provided by means of foam material on the inside of the hood By this measure a favourable result of 6 3% was achieved without applying any further auxiliary means

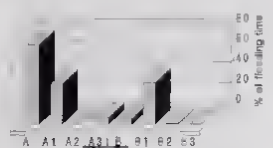

Fig 3 Additional buoyancy

During the test of the second suit a fixed inflatable Neoprene cushion was not inflated (B) and inflated (B 1 B 2) The unfavourable result of column B 1 was caused by the head slipping sideways on the cushion whereas in the case of column B 2 the head was fixed with adhesive tape in the right position When a life-jacket was used instead of the inflatable cushion (B 3) the flooding time was practically nil

DISCUSSION

It was important to find out the reasons for these significant differences why the nose and mouth were splashed so frequently and for such long times although the body lay in the water in a relatively high position due to the buoyancy of the insulating suits

According to the Dempster report [6] the spe

cific gravity of the whole body is 1 038 and that of the head 1 11 i e the body has nearly the same specific weight as water Thus it is floating in the water in a nearly neutral stability To keep the head in a safe upward position in the water the subject could theoretically be wearing a life-jacket efficient in calm water providing him with an additional buoyancy volume at the head of 4 5 kp corresponding with the average head weight This is the main construction of a life-jacket (*Fig 4*) Due to the buoyancy factor of the insulated immersion suit nearly the whole body is lifted to the water surface In this case the available buoyancy is insufficient to give additional lift to the head

Fig 4 Location in water

In order to simplify the calculation we can take the head as a globe which is covered up to 75% with Neoprene material of 7 mm thickness The head and the Neoprene together have a specific gravity of 0 95 This means that the head of the person wearing an immersion suit lies deeper in the water than the body if no additional buoyant material is provided This is not the case with life jackets.

Elsewhere the Norwegian Underwater Technology Center (NUTEC)[3] performed tests of immersion suits designed for crews and passengers of helicopters flying regularly over cold water Problems with respect to face splashing had been evident The author therefore recommended that the suits be provided with additional buoyancy The tests however were not related to rough sea but predominantly to hypothermia and to escape from a helicopter crashed into the sea

The introduction of immersion suits with thermal insulation—also designated in the Federal Republic of Germany as "survival suits"—means undoubtedly an important step in increasing the survival time of those in the water It has however to be pointed out that the test conditions provided by national and international regulations are insufficient, because they fail to ensure that life-saving appliances are tested also for efficiency in rough weather conditions This omission must be corrected and the additional tests should be carried out

Relatively small alterations may contribute a lot to more safety at sea Small quantities of buoyant material increase the freeboard (distance of the nose and mouth above the water surface) and water repellent insulating material loses its buoyant and insulating efficiency to a much lesser extent than others

The penetration of water into the immersion suits must not endanger life by either flooding the nose and mouth or by dangerously reducing the thermal insulation Quicker exhaustion and/or unconsciousness may be the result Therefore everything possible must be done to prevent splashing of the face and to make the suit water tight

We recommend to use

—immersion suits with adequate buoyancy in the hood and lined with non-absorbent material

—immersion suits without buoyancy in the hood together with an appropriate type of life-jacket only

Our tests were confined to those models of immersion suits approved by the Federal Republic of Germany for merchant shipping according to the IMO regulations and which were available at that time Undoubtedly there may be more appropriate models which are available but have not yet been approved for the use in the merchant fleet of the Federal Republic of Germany

ACKNOWLEDGEMENT

I wish to thank Dr E N Watson former Chief Medical Officer of the General Council of British Shipping who helped in preparing the English text

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Editorial Note

Splash Screens are fitted to RN Lifejackets to minimise the problem of wave splash Adequate support for wearers head and neck by correct inflation of the jacket is essential to their proper performance

* This study was supported by the Ministry of Youth Family Women and Health of the Federal Republic of Germany

J roy nav med Serv 1988 74 153–164

Actigraph Measurements of Work/Sleep Patterns during a Navy Operation

C J Brooks * D J Shergold,* R G Angus * R J Heslegrave* and D P Redmond†

Abstract

Crew sleep-wake patterns were investigated using the new technology of actigraphy. During a routine seven day coastal patrol in HMCS *Saguenay* the devices were worn by 20 personnel eight dayworkers, eight rotating shift watchkeepers and four senior crew. To assess the validity of actigraphic data the results were compared with subjective sleep reports. Analyses showed that the actigraphic estimates of sleep quantity exceeded the subjective estimates by about one hour for watchkeepers and senior crew. There was no difference between the two estimates for dayworkers. Reasons suggested for differences between actigraphic and subjective sleep quantity estimates are discussed. Further laboratory studies are required to determine threshold sleep values for the actigraph. Once these studies have been completed the actigraph will have great utility for helping to determine optimal work/rest/sleep regimes for operational environments.

INTRODUCTION

The safety and fighting effectiveness of a warship is dependent on the mental and physical efficiency of its crew. Principal maritime stressors which may deny efficient performance include extended familial separations, confined living conditions and discordant periods of work under difficult conditions. Typical warships' working environments might be described as enclosed workspaces built upon continuously moving and vibrating platforms in which complex tasks must be completed at all times of the day and night under adverse weather and dangerous operational conditions. Many of the crew also have to contend with problems of temperature extremes and noise. Such conditions can lead to feelings of fatigue or exhaustion, lower motivation and morale and physical illness or injury, with the end result being impaired performance.

Many maritime stressors are difficult to control, but some may be minimized. One area of concern is whether the discordant work/rest schedules imposed on ships' crews are appropriate for maintaining mental efficiency.[1] Discordant work periods occur because navies use rotating work schedules to facilitate around the clock operations. In these schedules crews' work/rest/sleep periods vary across day and night time hours with watchkeeping duties distributed so that personnel do not have to sustain long work periods. The theoretical rationale is that individuals perform more efficiently during short work periods than they do during longer periods.

This rationale is compromised, however, because the constantly changing periods of work seldom correspond with stable environmental/social time cues (ie day/night hours, normal meal times and normal work/sleep periods) which help to synchronize human internal or circadian rhythms. Typical of these rhythms is the daily change in body temperature which rises during the morning, peaks in the early afternoon and then decreases to a trough in the middle of the night, usually during sleep. There is evidence suggesting that other

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physiological systems and mental capabilities follow similar patterns [3-5]. When these rhythms and environmental cues dissociate eg immediately following long distance jet travel most people have problems sleeping and experience feelings of fatigue until their rhythms adapt to the new time cues. The navy watchkeeper's plight is similar except that it persists for the duration of the voyage because of constant desynchrony between his circadian rhythms and environmental cues.

Whether this desynchrony has a negative effect on performance efficiency in maritime environments has been the subject of several studies [6-12]. In most studies circadian rhythm changes were estimated by body temperature measurements but performance effects were only inferred. For example Colquhoun *et al* [10] found that the peak-to-trough amplitude of submariners temperature rhythm was reduced during operational conditions compared to shore based values. Since there are reports of a positive relationship between the amplitude of the body temperature rhythm and performance[3,12] it might be assumed that as the amplitude of the temperature rhythm of naval personnel decreases so does their performance.

After reviewing the results of several studies of rotating watch schedules Colquhoun[1] concluded that their only advantage is fairness in distributing unsocial hours of duty. The major disadvantages are that sleep becomes increasingly fragmented and circadian rhythms more varied. Because both sleep loss and circadian rhythm variations lead to decreases in alertness and cognitive performance in other environments[7,14-16] it is important that schedules optimal for the maintenance of crew capabilities be determined and utilized. This is especially important because the introduction of more technically advanced equipment has increased the demands on individuals cognitive abilities. For example although the probability of detecting submarines aircraft or other surface vessels has increased greatly with the development of new sensors success in future naval conflicts will be limited by how well operators assimilate sensor information and make appropriate tactical decisions. This will be especially difficult under the stress of sleep loss/fatigue which may occur as a result of the high intensity continuous operations envisaged for future conflicts if optimal work/rest schedules are not utilized. A major problem for determining optimal schedules however has been difficulty in obtaining reliable estimates of work and sleep amounts in operational environments.

A common method for obtaining sleep related data has been the use of subjective reports. But there is uncertainty about their validity and usefulness in predicting performance particularly under conditions of partial sleep deprivation[17]. A new approach has recently been afforded by the US Army's Walter Reed Institute of Research (WRAIR)[18] development of an actigraph monitoring system. The actigraph resembles a large wrist watch it contains accelerometers, which detect subtle arm and wrist movements and a microprocessor which aggregates the number of movements. Data records of several weeks duration can be stored and read later via microcomputer.

There have been several recent reports of the actigraph's utility in different environments. Gruen[19] reported its usefulness for determining the sleep/wake patterns of commercial aircrews. Storm & Parke[20] found the device useful for evaluating sleep patterns of high performance aircrews. And Redmond & Belinky[21] used the actigraph to obtain sleep information from infantry soldiers during continuous operations training exercises. In all cases the actigraphs permitted sleep measurement in conditions where subjective reports would not have been appropriate. While the use of actigraphy has many advantages validation studies are required as to its accuracy however.

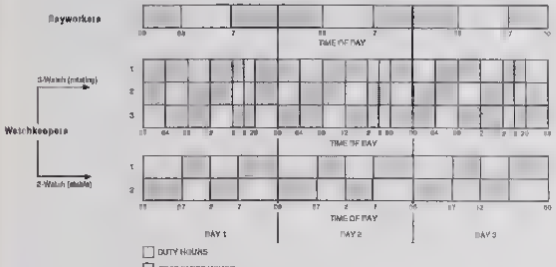
The present paper describes the use of the actigraph technology to study a Canadian Navy destroyer's crew sleep/wake patterns during a low intensity coastal patrol. It is the first actigraphic evaluation of sleep patterns of naval personnel during sea operations. The primary aims of the study were to collect baseline data for comparison with future high intensity operations; to compare subject completed sleep quantity reports with actigraph data and to compare the sleep quantity of dayworkers and rotating shift watchkeepers.

METHODS

Subjects

Twenty subjects were selected from the ship's company of HMCS *Saguenay*. Their average age was 34 and ranged from 25 to 49 years. Canadian Navy ships companies are usually divided into two groups dayworkers and watchkeepers". Dayworkers usually belong to support trades such as ships writers and stores-men. Watchkeepers have more operational de-

Table 1 Duty times and rest times (shaded areas) for dayworkers and watchkeepers. Included in the latter are both the 3-watch and 2-watch (stable) shift systems. The Table shows that the 3-watch system provides few opportunities for long sleep periods and that it is in general discordant with the work/sleep schedules and circadian rhythms of most people.



mands duties that require both day and night time work. The most common watchkeeping routine is the 3-watch "rotating" system. In high threat situations a 2-watch "fixed" system is used. These watch routines are summarized in *Table 1*.

The subjects in this study included eight dayworkers and eight watchkeepers. The other subjects were four senior officers and ratings: the Captain (CO), the Executive Officer (XO), the Coxswain (COXN) and Chief Engine Room Artificer (CERA) who do not follow regular work schedules. During high intensity operations their work periods can be very long, regimes that probably result in sleep deprivation. Under low intensity conditions these personnel work schedules similar to day workers.

Dayworkers selected were a ship's writer, storesman, hull technician, cook, electronics technician, senior boatswain, Radioman, and Engineering Officer. Watchkeepers selected were a Combat Systems Officer, Navigating Officer, an Officer of the Watch, weaponsman, junior boatswain, junior electrician, junior marine engineer, and a radar operator. They operated on a rotating 3-watch system and were selected from all three watch groups, labelled "1", "2" and "3" in *Table 1*.

Actigraph Sleep Measurements

The actigraphs were worn on the non-dominant wrist. Movements were summed in 7-min intervals. Waking periods were defined as three or more contiguous intervals of activity that exceeded the microprocessor's pre-set threshold level. Sleeping periods were defined as six or more successive intervals not achieving this criterion. Total sleep time and the number and duration of awakenings during each 24-hr period was read from the processor following completion of the trial. The data was analyzed relative to Greenwich Mean Time (GMT) or Zulu time to eliminate interpretation errors caused by time zone changes.

Subjective Sleep Measurement

Also used by the subjects was a personal sleep log (see *Fig 1*). On this form subjects indicated the amount of sleep they received during each 24-hr period. It was presented in local time with naval watchperiods superimposed to make completion easier. It was completed every morning.

Procedure

The study was conducted over a 7 day period. On the day prior to sailing, all volunteers were briefed on the purpose of the study, instructed

SLEEP LOG

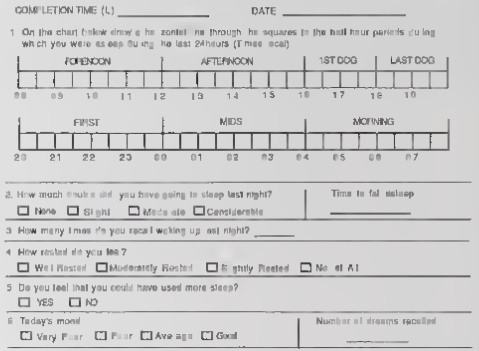


Fig 1 Illustration of subjective sleep log.

on how to complete the sleep log and issued their actigraphs During the trial personal interviews were conducted every two days each participant reported on the comfort of wearing the actigraph and any problems encountered in completing the sleep log

RESULTS AND DISCUSSION

Actigraphy Data Plots

Of the 20 actigraphs deployed complete data was collected from seven and partial data from nine No data was collected from the other four due to damage incurred during very rough sea conditions when they were knocked against bulkheads and machinery

Examples of the actigraph data are shown in *Figs* 2 and 3 Each of the figures displays data from noon to noon Zulu time for each of four days The figures show the cumulative activity for each 2 min interval as a vertical line Above each day is the actigraph system's interpretation of when subjects were asleep (black shading) or awake (no shading) The accumulated hours of sleep for each 24 hr period are indicated in the right margin in brackets

Figure 2 shows data from a dayworker subject Note the regularity of the sleep pattern from approximately 0300(Z) to 1000(Z) (local time 2300 h–0600 h) with occasional periods of low activity during the day which could be short naps In contrast *Fig* 3 shows data from an individual on the 3-watch system Note the multiple sleep episodes during each 24 hr period Although sleep was more fragmented for the watchkeepers a repeated measure analysis of variance of the actigraph sleep totals showed there was no difference in the amount obtained by watchkeepers and dayworkers [$F[1\ 59]=0\ 23$] Both groups slept about 9 5 hrs each day of the patrol

Comparison of Actigraph Data with Sleep Log Data

The primary aim of this study was to compare the quantity of sleep reported by the subjects on their sleep logs with the objective actigraph

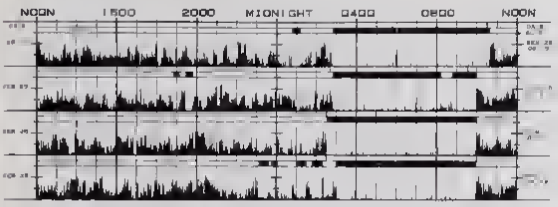


Fig 2 Actigraph record from a daywork r Data s displayed from noon to noon (Zulu) for each of four consecutive days Levels of activity are represented by the vertical l nes which ind cate the number of activity counts in each 2 min interval Black shading above periods of low activity counts indicates "sleep as interpreted by the actigraph system and no shading above high activity counts indicates awake Note the regular sleep times across the 24-hr period for this subject

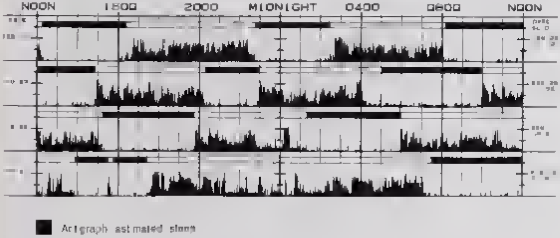


Fig 3 Actigraph record from a "watchkeeper Note the multiple sleep episodes during each 24-hr period for this subject

totals Although the actigraphs are relatively unobtrusive "wear and forget" devices there is a need to validate their sleep quantity estimates This need is illustrated in the present study because although as noted above the actigraph data indicated that there was no difference in the amount of sleep obtained by dayworkers and watchkeepers a comparison of their sleep log data indicated that, on average the dayworkers reported sleeping about 9 0 hrs per 24-hrs while the watchkeepers reported 7 5 hrs [$F(1\ 59) = 7\ 72$ $p<0\ 01$] Further comparisons of the sleep log (subjective) and actigraph (objective) data follow

Figure 4 shows the objective and subjective estimates of total daily sleep for each day of the patrol. Note that the actigraph measures of sleep quantity consistently exceeded the subjective estimates To determine whether this difference was reliable the data from all subjects who had complete objective and subjective data for the 7-day trial were analyzed using a repeated measure analysis of variance procedure This analysis showed that the objective

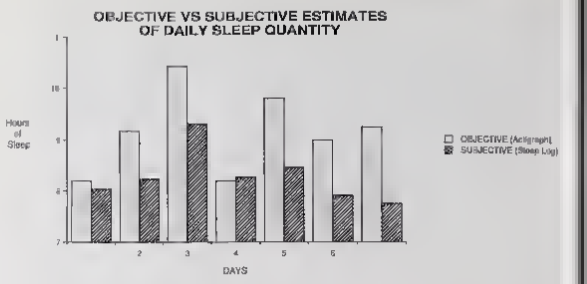


Fig 4 Objective (actigraph) and subjective (sleep log) estimates of sleep quantity for each day of the patrol

estimates of sleep significantly exceeded the subjective estimates by 56 minutes [(F(1,6)=7 56 p<0 05]

The same analysis was also conducted over the first 3 days for 16 subjects who had completed objective and subjective data on those days Again the objective estimates of sleep significantly exceeded the subjective estimates [F(1 15)=5 48 p<0 05)] A further comparison was made to determine if the objective and subjective measurements of continuous sleep periods were coincidental Descriptively this is shown by superimposing the subjective start and stop times of sleep from the sleep logs over the objective horizontal bars of actigraphy data defined as sleep *Fig* 5 is an example of the temporal coincidence of sleep for a subject with very similar total objective and subjective amounts of sleep

As shown in *Fig* 5 on February 24 27–28 and March 2 there were some short periods of low actigraph activity that were not indicated in the subject s sleep log These periods may be periods of low activity thatm were misinterpreted as sleep by the actigraph system or the subject may not have noted that he was napping in his sleep log The figure also shows slight differences in start and stop times of the subjective and objective sleep periods

Causes for Differences in the Objective and Subjective Data

To determine possible causes for differences between objective and subjective estimates of sleep quantity the isolated periods of low activity that were interpreted as sleep were summed across subjects and compared to the difference between the objective and subjective estimate of total daily sleep This result is displayed in *Fig* 6 Analysis of the data indicated there was a significant correlation ($r=0\cdot87$ $df=79$ $p<0\cdot01$) between the difference scores and the isolated periods of low activity which provides one possible reason for the significant difference between the two estimates of daily sleep

A further analysis of the actigraph and subjective estimates of sleep was done by comparing the sleep quantity of the dayworkers watchkeepers and senior crew members. As shown in *Fig* 7 these three groups had significantly different objective/subjective sleep estimates [F(2 4)=14 75 p<0 01] When the actigraph and subjective quantities of sleep were compared for individual groups, it can be seen that the dayworkers subjective estimates were not significantly different from the actigraph data [t(46)=0·05] However both the watchkeepers [t(46)=2 38 p<0 02] and senior crew [t(38)3 08 p<0 01] subjective estimates were significantly less than the actigraph s estimate of daily sleep quantity

Thus it appears that the actigraph has difficulty in discriminating between naps rest and/or quiet periods of low activity eg, when subjects are reading while lying down in their bunks *Fig* 8 shows an actigraph record taken

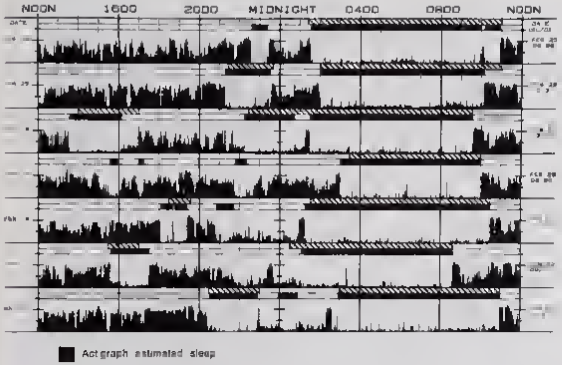


Fig 5 Actigraph record with a comparison of sleep log (diagonal line shading) and actigraph (dark shading) estimates of sleep periods

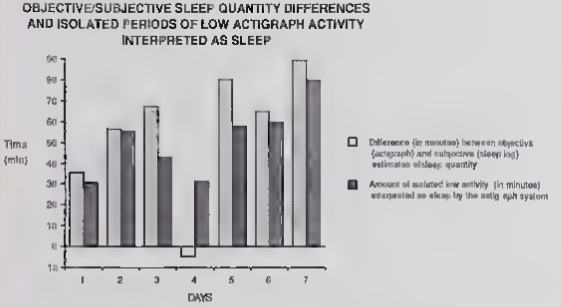


Fig 6 Comparison of daily amounts of isolated periods of low actigraph activity interpreted as sleep by the actigraph system with difference between objective and subjective estimates of sleep

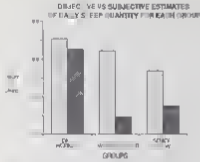


Fig 7 Objective and subjective sleep quantity estimates for dayworkers watchkeepers and senior crew

from a dayworker with vertical bars indicating the reading times reported in his sleep log There are four such reading periods three of them are classified as sleep by the actigraph

Low activity periods could also have occurred when personnel do administrative work at their desks *Fig* 9 shows an actigraph plot of an officer who worked a dayworker schedule Actigraphic sleep is indicated during his normal working hours although he could have taken an on the job nap which was not noted in sleep log

Another difference between actigraph and subjective sleep measurements is their discrepant indications of sleep onset and offset times This is illustrated in the *Fig* 10 plot of an actigraph record from an Officer of the Watch which shows that his subjective estimates of sleep time (indicated by the diagonally shaded bars) do not always agree with the actigraphic estimate One reason for the discrepancies may be that subjects cannot recall when they fell asleep or woke up especially if several hours pass before the sleep log estimate is made This may be more of a problem for watchkeepers (because their work/rest times are always changing) than for dayworkers who usually go to sleep (and wake-up) at regular times Because watchkeepers fragmented sleep schedules probably contribute to feelings of fatigue it is possible that these subjects underestimate the amount of sleep they actually receive (ie they feel tired so they report receiving little sleep) A last reason may be reluctance on the subjects' part to admit to sleeping on the job!

Although subjective underestimation may be part of the reason for the difference between the watchkeepers actigraphic and subjective sleep quantity estimates (see *Fig* 7) another reason is that watchkeepers probably perform less physical activity than dayworkers As indicated in *Figs* 8 and 9 periods of low activity are sometimes interpreted as sleep by the actigraph software system Thus, the actigraph system may be overestimating the amount of sleep that these subjects received

The latter reason is supported by the data from senior crew personnel Although these subjects worked essentially dayworker schedules (ie their sleep and wake-up times were stable) during this routine patrol more sleep was indicated by the actigraph system than was reported in the sleep logs This could have been caused by the fact that senior crew do more administrative work than dayworkers hence

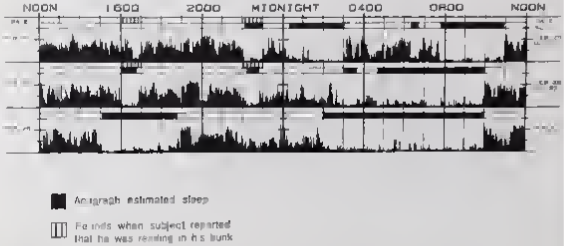


Fig 8 Actigraph recording indicating times when a subject reported that he was reading in his bunk (vertical line shading). Note that four of these periods are interpreted as sleep by the actigraph system

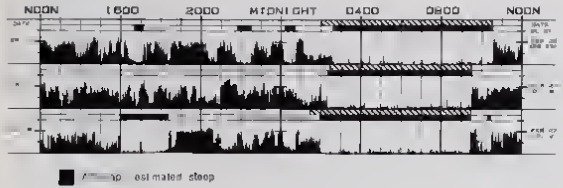


Fig 9 Actigraph record indicating sleep (dark shading) when subject was performing administrative duties (diagonal line shading)

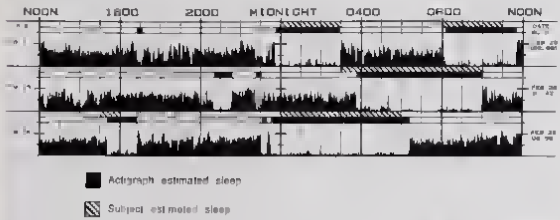


Fig 10 Actigraph record indicating some discrepancies between sleep log estimates (diagonal line shading) and actigraphic estimates (black shading) of sleep onset and wake-up times

desk work may have been interpreted as sleep by the actigraph) On the other hand the actigraph may in fact have been identifying times when the subjects were napping. This is possible because senior crew may be required to work at any time often for many continuous hours hence to compensate they have learned to take naps whenever they can.

It should be noted however that there were no significant differences between the actigraph and subjective sleep data for dayworkers Possible reasons for this finding are the normal regular daily work/sleep routine of these workers probably facilitated an easier recall of actual sleep periods the majority (six of the eight subjects) of dayworkers duties involved physical activity Thus when subjects duties involve physical activity and regular work/rest/sleep schedules there is a close correspondence between the actigraph and subject defined sleep

Comfort and Safety of Actigraphs

The participants were requested to provide comments related to the device s unobtrusiveness and comfort Many personnel reported difficulties getting used to wearing the actigraphs some had problems when rough sea conditions increased their need to maintain support and balance with their hands Another concern was that extended wear induced minor skin irritations especially during physical activity this was reported by 14 subjects In terms of safety several comments were made concerning the sharp edges of the actigraph pressing against the wrist Upon completion of this study the actigraph edge surfaces were rounded

and smoothed and covers made to reduce skin chaffing

CONCLUSIONS

A study of the sleep patterns of dayworkers and watchkeepers in the ship's company of a Canadian Navy destroyer has been successfully completed using actigraphs They were used to objectively quantify the sleep obtained by personnel on different shift schedules during a low intensity coastal patrol The actigraphs worked well except during very severe weather conditions when several units were damaged because they were unavoidably knocked against bulk heads and machinery With regard to differences in the amount of sleep obtained by dayworkers and watchkeepers the actigraph data indicated there was no difference Both groups received about nine hours of sleep during each 24-hr period However according to their subjective reports dayworkers said they received about 9 2 hrs of sleep per 24-hr period while watchkeepers said they received 7 5 hrs Thus the actigraphs consistently over-estimated sleep by more than an hour of the watchkeepers compared to their subjective reports but, for those who were dayworkers whose duty involved a lot of physical effort the measurement of objective and subjective sleep compared very well Inconsistencies between objective and subjective sleep may be explained as follows

(a) watchkeepers had some difficulty recording their exact periods of sleep time when completing the sleep logs
(b) the actigraph sometimes interpreted low activity work (e.g. desk jobs) as sleep
(c) the actigraphs may have identified nap ping that wasn't admitted to in the sleep log

RECOMMENDATIONS

Actigraphs should continue to be used as an unobtrusive method for evaluating the sleep patterns of personnel in sea operations How ever carefully controlled laboratory studies should be done to determine sources of discrepancy with subjective sleep quantity reports and to define the actigraph's sleep/wake threshold settings. In the meantime subjective sleep logs should continue to be completed during operational trials to assist in the identification of times when the actigraph indicates the occurrence of sleep during periods of low physical activity The actigraph technology should now be applied to examine the sleep pattern of a ship's company during high demand naval operations From this data a better understanding of different naval shift work systems will be gained

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J roy nav med Serv 1988 74 165–172

The Influence of Periodontal Screening upon Dental Hygienist Practice in the Royal Navy

A J Woodman

Abstract

Treatment patterns and times were observed for 616 Royal Naval personnel following routine referral to a Dental Hygienist. Results were then related to the patient's periodontal status recorded at their initial examination using the Periodontal Index for Treatment to determine whether the Index would allow prediction of the treatment necessary for such patients and whether the Index was being used as intended for prioritisation of resources for periodontal care. Results indicated that both the treatment time and oral health education time for each patient were related to the Index and thus to disease severity. However the results failed to show that the Index was used for prioritising periodontal care and suggested that Dental Hygienist practice is dominated by the treatment of patients with little or no periodontal disease to the disadvantage of a minority of patients requiring intensive therapy for destructive periodontal disease.

INTRODUCTION

Royal Navy Dental Officers are required as part of routine annual dental inspections, to examine the periodontal tissues and award an assessment based on pocket probing and gingival bleeding on a non parametric scale 0 1 2 3. This score is known as the Periodontal Index for Treatment (PIT) and its codes indicate the nature of further treatment required to allow prioritisation of patients thus

0=Health no further treatment other than possible stain or minor deposit removed supragingivally

1=Gingivitis bleeding on probing but no pocketing in excess of 4 mm. Dental hygiene therapy and OHI required

2=Pocketing >4 mm but <6 mm. Evidence of destructive periodontal disease requiring subgingival therapy from Dental Hygienist (or Dentist)

3=Pocketing >6 mm. Evidence of advanced periodontal disease requiring complex therapy

When codes 2 and 3 are recorded for any of the six test teeth

6	1	6
6	1	6

a full periodontal examination for other diseased sites is indicated prior to planning treatment or referral to the Dental Hygienist (DH). The validation of this technique was described by Eaton and Woodman in 1986.[1]

The aims of this study were to determine

a. whether PIT codes give an indication of clinical time necessary for treatment,

b whether PIT code 2 or 3 patients are given priority when allocating dental hygienist appointments

c. whether Dental Hygienists are being required to treat low score patients for aesthetic reasons in preference to those with known advanced disease and

d. the proportion of the DH day occupied by each code.

Surgeon Commander (D) Woodman is Commander Dental Training at HMS Nelson

PIT STUDY RECORD HMS _____

Patient Name _____ Rank/Rate _____ No _____

Code at Commencement PIT 0 1 2 3

Attendance Record with DH * Time (mins)

							Task			
*Appt No	1	10	20	30	40	60	Sc	RP	Pol	OHI
	2	10	20	30	40	60	Sc	RP	Pol	OHI
	3	10	20	30	40	60	Sc	RP	Pol	OHI
	4	10	20	30	40	60	Sc	RP	Pol	OHI
	5	10	20	30	40	60	Sc	RP	Pol	OHI

Others

Total Time _____

_____

* Please circle appropriate Time and Task in RED
# Do *not* complete

This form should be used *at each DH attendance* to record the time taken and tasks performed—where two tasks are performed in one visit the time for each should be noted separately using different colours or marks thus

Appt No 1 (10) ~~20~~ 30 40 60 ~~Sc~~ RP Pol (OHI)

would indicate a 30 minute appointment with 20 minutes Scaling, +10 minutes OHI

Fig 1 TREATMENT QUESTIONNAIRE
KEY Sc —Scaling
RP —Root Planing
Pol —Polish
OHI—Oral Health Instruction

METHOD

Four Royal Navy establishments in the Portsmouth area having stable dental officer and hygienist population and not subject to wide patient mobility were chosen for study. HMS *COLLINGWOOD DAEDALUS DOLPHIN* and *SULTAN*

The study involved the Dental Hygienist in each establishment completing a work related questionnaire (*Fig 1*) over a three month period, allowing assessment of the treatment patterns for 616 patients

Each of the 616 patients received a course of dental hygienist treatment during the study period (May to September 1987) and the questionnaires were returned for scrutiny on completion of treatment. The total time taken for each patient was assessed and related to the number of appointments used and the PIT code on initial referral. The proportion of actual clinical treatment was compared to the time spent upon oral health instruction. The proportion of PIT codes on referral was compared to the distribution of such codes found in a sample of Royal Navy personnel in a previous study by Eaton and Woodman [1]

RESULTS

Considering all patients the mean time for a course of dental hygienist treatment was found to be 40 minutes including 12 minutes of oral health education over 1.5 appointments (*Table 1*). The variation between establishments was small.

The initial PIT codes on referral (67%) reflected the predominance of PIT 1 patients (63.5%) previously found by Eaton and Woodman [1] as shown in *Table 2*. Higher numbers of PIT 0 patients were seen by the hygienists than were shown to be present in the Naval popula-

Table 1 Appointments Duration and oral health education time by establishments

Establishment	Collingwood	Saltan	Daedalus	Dolphin	All
Patients	223	215	102	76	616
Time (minutes)	9 130	8 590	4 160	2 500	24 380
Mean time	41	40	41	33	40
Appointments	313	362	149	97	821
Mean appointments	1 4	1 7	1 46	1 28	1 5
OH Time (minutes)	2 850	2 730	970	960	7 510
Mean OH Time	13	13	9 5	13	12 3

Table 2 % Time consumed by PIT code compared with % incidence of PIT code in RN patients

PIT code	0 Clinically healthy	1 Gingivitis	2 Early periodontitis	3 Established periodontitis
% RN patients*	8	63 5	26 5	2
% DH patients	21	67 1	10 1	2
% DH time	15	66 1	16 1	3

* From Eaton and Woodman 1988 [1]

tion When compared to the time consumed by each code the PIT 1 patients proved dominant (66%) The percentage of PIT 2 and PIT 3 patients treated is those with detectable periodontal breakdown was 12% whereas in the sample from the previous study by Eaton and Woodman [1] 28 5% of the sample population were categorised in that group

Treatment times and appointments consumed considered by PIT code are contained in *Table* 3

Data for the periodontitis patients, in PIT 2 and PIT 3 categories, have been combined in *Table* 4 to reflect those having destructive periodontal disease rather than gingivitis (PIT 1) or those clinically healthy (PIT 0) These data showed mean treatment times increasing with the Periodontal Index for Treatment thus PIT 0 patients required 27 4 minutes over 1 07 appointments PIT 1 39 2 minutes over 1 5 appointments PIT 2 59 7 minutes over 2 2 appointments and PIT 3 80 minutes over 2 8 appointments These data also show the amount of time within the whole devoted to oral health instruction once again increasing with increasing PIT code PIT 0 patients received a mean of 9 minutes of OHI PIT 1 12 3 minutes PIT 2 20 minutes and PIT 3 23 3 minutes

Table 4 shows the combined data for PIT 0 and PIT 1 patients those having a clinically healthy (0) periodontium and those with gingivitis (1) who would be expected to require minimum treatment with those showing signs of destructive disease scored by the PIT index when pocketing greater than 4 mm in depth is present and categorised as PIT 2 or 3 Although the sample sizes are disparate the trend towards greater treatment time is clearly evident

Table 5 shows the breakdown of appointments required to achieve a complete course of hygienist treatment Only 35 (5 5%) patients required three of more appointments, whilst over half (356 or 58% were treated in a single appointment and 225 (36 5%) in two appointments By PIT code the proportions treated in a single appointment showed a steady decline from 94% (PIT 0) to 55% (PIT 1) to 13% (PIT 2+3) Two appointments were required by a proportion increasing by code thus 6% (PIT 0) increased to 41% (PIT 1) and 63% (PIT 2+3) Three or more appointments were required by 4% of PIT 1 patients and 24% of PIT 2+3 patients

Oral health instruction time was limited to ten minutes in the majority of the patients (442 or 72%) shown in *Table* 6 One hundred and eighteen (19%) received a further ten minutes

Table 3 Appointments duration and oral health educat on time by PIT codes 0 1 2 and 3

Establishment	Collingwood	Sultan	Daedalus	Dolphin	All	Collingwood	Sultan	Daedalus	Dolphin	All
PIT code	PIT 0					PIT 1				
Total patients	60	50	4	17	131	150	138	73	49	410
Appo ntments	64	55	4	17	140	210	239	89	61	609
Mean appo ntments	1 1	1 1	1	1	1 07	1 4	1 7	1 4	1 25	1 5
% Total pts	26 9	23 2	3 9	22 4	21 4	67 3	64 2	71 5	64 5	67 1
Total time[1]	1 760	1 350	70	410	3 590	5 190	5 550	2 780	1 550	16 070
Mean time[1]	29 3	24 5	17 5	24 1	27 4	41 3	40 2	38 1	31 6	39 2
OH time[1]	510	500	10	180	1 180	2 020	1 730	710	600	5 060
Mean OH time[1]	8 5	10	2 25	9 4	9	13 5	12 5	9 7	12 3	12 3
PIT code	PIT 2					PIT 3				
Total patients	9	21	23	10	63	4	6	2	—	12
Appo ntments	27	51	41	19	138	12	17	5	—	34
Mean appo ntments	3 0	2 4	1 8	1 9	2 2	3 0	2 8	2 5	—	2 8
% Total pts	4 1	9 8	22 6	13 1	10 3	1 7	2 8	2 0	—	1 96
Total time[1]	810	1 250	1 160	540	3 760	370	440	150	—	960
Mean time[1]	90	59 5	50 4	54	59 7	92 5	73 3	75	—	80
OH time	210	350	230	200	950	110	150	20	—	280
Mean OH time[1]	23 3	16 7	10	20	15 7	27 5	25	10	—	23 3

[1]=Minutes

Table 4 Appointments duration and oral health education time for health/gingivitis (PIT 0/1) and destructive periodontal disease (PIT 2/3)

Establishment	Collingwood	Sultan	Daedalus	Dolphin	All	Collingwood	Sultan	Daedalus	Dolphin	All
PIT code	PIT 0+1					PIT 2+3				
Total patients	210	188	77	66	541	13	27	25	10	75
Appointments	274	294	103	78	749	39	68	48	19	172
Mean appointments	1 3	1 56	1 34	1 2	1 38	3 0	2 5	1 8	1 9	2 3
% Total patients	84 2	67 4	75 5	86 9	87 7	5 8	12 5	24 5	13 1	12 3
Total time (minutes)	7 960	6 900	2 850	1 960	19 660	1 180	1 680	1 310	540	4 720
Mean time	37 85	36 7	37 0	29 7	36 3	31	62 5	52 4	54	63
OH time (minutes)	2 530	2 230	720	760	6 240	320	500	250	200	1 270
Mean OH time	12 05	11 86	9 35	11 5	11 53	25	18 5	10	20	17

Table 5 Number of appointments required by code

Pit code	0	1	2	3	All
Single appointment	122	224	8	2	356
2 Appointments	9	169	43	4	225
3 Appointments	—	15	9	2	26
4 or more (N)	—	2(4)	3(2 (5))	4(3 (4))	9
Total pts	131	410	63	12	616

Table 6 Time spent in oral health education by code

PIT code	0	1	2	3	All
10[1] OHI	104	290	42	6	442
20[1]	7	95	13	2	118
30[1]	—	12	3	1	16
40[1]	—	2	2	2	6
50[1]	—	—	2	1	3
Nil	20	10	1	—	31
Total pts	131	410	63	12	616

[1] = Minutes

instruction but only 25 (4%) had 30 minutes or more Thirty one (5%) patients were treated without receiving any OHI during their treatment

Of those receiving 30 minutes or more OHI fourteen were PIT 1 (3 4% of PIT 1 patients) 11 were PIT 2 or 3 (15% of PIT 2 and 3 patients)

DISCUSSION

Incidence of the PIT 1 Code is comparable with that found in Service patients by Eaton and Woodman[1] ie 67% of DH patients were PIT 1 compared with 63 5% in their survey However whilst only 8% of such Service patients were found PIT 0 by Eaton and Woodman,[1] 21% of DH patients studied were PIT 0 on referral.

PIT 2 and PIT 3 figures were only 12% in the DH patients but had an incidence of 28 5% overall within the Service sample suggesting that only half those with destructive periodontal disease are receiving periodontal treatment This may indicate

a a failure to diagnose the early periodontitis (PIT 2) state or

b that preference for treatment is given to those with relatively clean mouths (PIT 0/1) and many patients with destructive disease are not considered deserving of treatment

The amount of time spent on OHI increased with PIT Coding, as did the overall treatment time which would be expected However few of the patients received follow-up OHI on a second appointment considered desirable by most periodontists to assess compliance with new regimes.

Numbers of appointments rarely exceeded two This may well reflect

a the traditional clinical training pattern for hygienists—gross scale first and fine scale second—which pays little regard to the particular patient s needs or

b the lack of adequate prescription from the referring dental officer to plan treatment and review or

c a failure to appreciate the need for observation or recall in periodontal disease patients

The overall mean time for treatment compares with that reported by Ekanayaka and Sheiham[3] in an industrial clinic Their findings showed a mean of 35 minutes of time spent upon each patient, including eight minutes of oral health education whereas in this study a mean of 40 minutes including 12 minutes of education were observed However Ekanayaka and Sheiham[2] also observed that treatment times in a hospital periodontal department

showed a mean of 73 minutes of scaling with 55 minutes of oral health education considerably more than most of the PIT 2 and 3 patients in this study, yet the practising environment of the RN Dental Hygienists is free from the economic restrictions placed on those in the industrial clinic and thus facilitates lengthy sessions of treatment where necessary.

Ekanayaka and Shetham[2] also observed that treatment times increased in both clinical and oral health education components as the periodontal index (and thus disease severity) increased as found with the changing PIT scores in this study.

The overall result of the study was disappointing in that broadly the types of patients treated reflected the PIT Code incidence expected within the Service. This indicates a lack of prioritisation—the object of the code—and thus raises several questions:

1. Should dental hygienists spend 15% of their time treating patients with zero clinical signs of disease (PIT 0)?
2. Should 66% of the hygienist's time be devoted to patients with gingivitis when it is accepted that only a small proportion of these patients will later develop periodontitis?
3. Should only 19% of the hygienist's time be associated with patients having destructive disease, who are those at risk of further tooth loss, acute infection or abscesses and thus are deemed the priority group of the PIT system?

It is possible to conclude from these observations that as yet the PIT technique for prioritisation of periodontal care resources is not being used as intended and that prescription of dental hygiene therapy is still often made by visual signs of poor oral hygiene rather than clinical signs of disease. Establishing priorities for treatment has not yet become routine to the disadvantage of both the periodontally affected patient and the working practice of the dental hygienist whose time is dominated by the treatment of personnel for minor non destructive disease or for aesthetic reasons. This may in some way explain the pressure upon such hygienists to restrict their time and appointments for the provision of deserving and often rewarding treatment to those with destructive periodontal disease. Such patients require long and intensive therapy but regrettably are often regarded as being mere hopeless cases and as such are relegated to the inevitability of dentures, at the expense of the cleaner mouth which is more pleasant to treat yet has little or no disease. Used more conscientiously by referring dental officers, the Periodontal Index for Treatment may in the future begin to redress the balance in periodontal care.

ACKNOWLEDGEMENTS

The author wishes to thank the Director of Naval Dental Services for permission to conduct and publish this study. The author also wishes to thank the dental officers and hygienists who so kindly cooperated in the completion of the treatment questionnaires.

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Some Haematopathological Features of Marathon Running

C Pipkin

Abstract

Over the last decade marathon running has become an increasingly popular sport. There were over eighty thousand applicants for the 1987 London marathon and nearly twenty thousand runners eventually realised their ambitions and crossed the finishing line. The potential for scientific study of the effects of running for a little over twenty six miles on human physiology and metabolism has not gone unrealised and a large and increasing body of literature on this and related subjects can now be found. I was fortunate enough to run in the 1987 London marathon and undertook a simple study of the effect of the run on various haematological parameters. This article presents a brief review of some of the more important haematopathological features of long distance running together with my own personal observations.

INTRODUCTION

The first marathon was run by Pheidippides in 490 BC from Marathon to Athens in order to bring news of the victory by Miltiades over the Persians. Although Pheidippides is reported to have collapsed and died after the run he has not served as a discouraging example and in recent years there has been a marked increase in the popularity of marathon running.

Road running for 42.2 Km puts a severe stress on muscles and joints cardiovascular system water balance and thermoregulation. Marked body weight losses of up to 6.1 Kg sweat loss in excess of 4.7 L and rectal temperatures in excess of 40°C have been observed at the end of marathon races[1]. If the duration of running varies from 2.5 to 3 hours it can be estimated that total energy consumption during the race in an athlete utilising 75–80% of maximum aerobic power is in the order of 2 400–2,800 Kcal more than that consumed during 24 hours of sedentary life[2].

Prolonged running and muscle contraction results in a release of intramuscular enzymes, including creatine kinase and aminotransferases and in a synthesis of acute phase proteins, including C reactive protein and endogenous pyrogen or interleukin 1. This acute phase response during running is probably induced by endotoxin released from muscle. Endotoxin may act on macrophages to release interleukin 1 stimulating the liver to produce other acute phase proteins.

During marathon running heat is produced by contracting muscle at a rate of 700–1,200 Kcal/hour. In addition heat gain due to incident solar radiation has been estimated at 150–200 Kcal/hour[3]. This degree of heat production is some 15–16 times the basal rate and heat production of this magnitude would raise the body temperature by 1°C every 5 minutes if no temperature regulatory mechanisms were activated. Hypothalamic regulatory centres attempt to maintain the balance between heat production and dissipation. Dissipation of heat occurs by radiation (60%) conduction (2%) and convection (3%) from the body surface and by evaporation from skin and lungs (30%). These proportions vary with environmental conditions and when the ambient temperature reaches 35°C evaporation becomes the major mechanism responsible for heat loss.[4]

Exercise alters fluid homeostasis between different body compartments and results in fluid and electrolyte loss to the environment.

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The magnitude of sweat production during running depends on a multiplicity of factors including the rate of energy expenditure (running speed) the cooling power of the environment and inherent variations in the runners themselves but may be up to 2 L/hour With these various heat dissipation mechanisms operating rectal temperature usually increases to 38 39°C during a marathon run

The effects of these various mechanical and physiological stresses and the failure of normal homeostatic corrective mechanisms may produce numerous medical problems including hypovolaemic collapse hyperthermia and hypoglycaemia apart from the recognised muscle and joint complications

Much has been written on the effects of strenuous exercise on human physiology and the mechanisms that maintain homeostasis some of which has been outlined above The effect of exercise on various haematological parameters has perhaps attracted rather less attention The acceptance of my application to run in the 1987 London marathon afforded me the opportunity to study these effects first hand Before describing my own observations, I should like to present a brief review of three well-documented consequences of long distance running on haematological parameters namely neutrophil leucocytosis abnormal haemostasis and anaemia

REVIEW

Leucocytosis

Marked leucocytosis occurs with strenuous exercise Counts as high as 22.0×10^9/L have been recorded for a runner after making a 100 yard dash in 11 seconds and 35.0×10^9/L on completing a quarter mile run in less than a minute [5] A more recent study has shown that a short period (30 minutes) of vigorous recreational exercise (swimming squash or jogging) can induce a substantial delayed leucocytosis with peak leucocyte counts recorded between 2 and 4 hours after exercise [6] The increment of cells is usually made up of neutrophils and in the case of the immediate leucocytosis is due to a shift of cells from the marginal sites to the circulating pool Margination is the tendency for leucocytes to congregate along blood vessel walls outside the axial stream of blood flow Since this leucocytosis occurs in the absence of the spleen this organ would not appear to be a major site of cell margination It has been suggested that the delayed leucocytosis reported by McCarthy *et al*[6] may occur as a result of the action of cortisol on the bone marrow

Leucocyte counts above 20.0×10^9/L, again mainly neutrophils, are regularly recorded for runners completing a marathon in 2½–3 hours. There is disagreement as to whether a shift to the left in neutrophil morphology suggesting mobilisation of marrow neutrophils occurs in this circumstance Post marathon leucocytosis subsides slowly over a number of hours

Gimenez *et al*[7] have shown that leucocytes increase at submaximal levels with a marked increase at maximum aerobic power It seems therefore that the maximum increase in leucocytes is more related to the maximal intensity of exercise than to its duration

Several studies have shown that the pulmonary circulation is the important reservoir of the marginated leucocytes that are recruited in exercise The mechanism by which this demargination occurs is not clear and several possibilities exist. An increase in pulmonary blood flow might mechanically increase the release of leucocytes from the lungs A redistribution of blood flow to lung regions sequestering leucocytes might have the same effect. Alternatively there is a possibility that as catecholamines increase during exercise they specifically influence the interaction between leucocytes and endothelial cells [8] Lymphocytes granulocytes and endothelial cells all contain β_2 receptors

Foster *et al*[8] examined the effect of β-adrenergic blockade on the leucocytosis of exercise and found that the rise in total leucocyte count was unaffected by non selective β-blockade They concluded that the probable cause of demargination of leucocytes is the mechanical effect of the increase in cardiac output Whether demargination results solely from increased blood flow or as a redistribution of the increased flow within the lungs remains unclear This conclusion presupposes that the leucocytosis of exercise is not due to some other humoral event that decreases granulocyte adherence to endothelial cells.

It has been suggested that the leucocytosis along with other immunological and metabolic responses to exercise including the rise in body core temperature and increased plasma levels of acute phase proteins such as C reactive protein caeruloplasmin, fibrinogen and α proteinase inhibitor is related to the class of compounds referred to as endogenous pyrogen leucocyte endogenous mediator or interleukin 1[9] It has also been demonstrated that physical exercise causes activation of monocytes and

macrophages and that these activated cells secrete endogenous pyrogen

In a recent study the effect of physical exercise on the activation of polymorphonuclear leucocytes as measured by the release of polymorphonuclear elastase complexed with α_1 proteinase inhibitor (E α_1-PI) confirmed the rise in leucocyte count in response to exercise (in the form of a 10 km run) and in addition showed a marked increase of E α_1-PI activity (of up to 186%) suggesting that this compound was released by degranulation of neutrophils during prolonged physical activity [9] Particularly high levels of E α_1 PI have been observed during bacterial infections and the authors suggest that the response of polymorphonuclear leucocytes to physical exercise is similar to an infectious or inflammatory challenge

Haemostasis

Transient changes in factor VIII (F VIII) activity have been known for some years to occur in a number of well-defined and often stressful situations including physical exertion [10]

In 1960 Ingram[11] demonstrated that the intravenous infusion of adrenaline raised the potency of what was then known as antihaemophilic globulin (AHG) in the plasma of normal subjects and of mildly affected haemophiliacs In the same year Rizza[1] demonstrated that there was a marked increase in the activity of AHG after exercise The average AHG level of blood taken 6 hours after exercise was still about 60% higher than the control level In further experiments it was reported that there was no increase in the levels of Christmas factor (factor IX) factor V prothrombin or fibrinogen after exercise The rise in F VIII in the exercised subject seemed to be related to adrenergic stimulation because it had been shown to be blocked by prior administration of the β-adrenergic blocker propranolol [10]

In more recent years further elucidation of the mechanisms of haemostasis has enabled more elaborate experiments to study the effect of strenuous prolonged exertion on blood platelet activation and thrombin activity

In the haemostatic process platelets once activated release many substances which influence the coagulation cascade including ATP ADP AMP and cAMP as well as platelet specific proteins including β thromboglobulin (β-TG) and platelet factor 4 (PF 4) Blocker *et al*[12] analysed the haemostatic system after the influence of prolonged physical exertion with particular interest being paid to in vivo indicators of platelet activation (β TG PF 4) and thrombin activity (fibrinopeptide A FPA produced in the conversion of fibrinogen to fibrin under the action of thrombin) Following a marathon run (mean time 2 hrs 44 5 mins) marked activation of platelet function and coagulation was observed Immediately after the race β TG PF 4 and FPA rose significantly Factor VIII activity increased 3 fold and significant shortening of the partial thromboplastin time (PTT) a measure of the activity of the intrinsic system of coagulation was recorded Factor VIII was significantly elevated throughout the observed recovery period and was still high 22 hours after the race The prothrombin time (PT) a measure of the extrinsic pathway of coagulation and fibrinogen concentration did not change significantly after the race or in the rest period

The response of platelets to exercise is of fundamental physiological and pathological interest There is increasing evidence that platelet interaction with the vascular endothelium may play the crucial role in the pathogenesis of atherosclerosis While the exact mechanisms and regulatory pathways concerning exercise induced platelet aggregation and release are not completely understood, the following mechanisms are probably involved

—exercise induced circulatory activation resulting in the mobilisation of newly formed and more metabolically active platelets from the pulmonary vessels
—thrombin generation due to activation of the intrinsic coagulation pathway
—endothelial damage due to shear stress followed by blood flow increase resulting in collagen exposure—the most potent aggregation factor
—excess rises in plasma levels of catecholamines

Other factors probably involved are increased body temperature lactate acidosis and marked haemoconcentration Two other mechanisms specifically related to marathon running are of interest The mechanical destruction of erythrocytes due to prolonged running may play an important role in platelet activation due to the resultant liberation of red cell ADP Endurance running may induce muscle fibre necrosis and degeneration in exceptional cases resulting in clinical rhabdomyolysis and myoglobinuria It has been estimated that 60 g of muscle is damaged in a

marathon race It is known that massive tissue injury causes release of tissue thromboplastins, hyperactivity of the arachidonate pathway and a rise in factor VIII Whether the relatively small amount of muscle damage due to prolonged running has importance in activation of platelets has not been determined

The exact mechanism of the exercise-induced increase in factor VIII is not known but release from endothelial cells is probably the major mechanism involved. The rise in F VIII is mediated by β_2 receptors and can be eliminated by β-blockade

These haemostatic observations may become very significant Disseminated intravascular coagulation as defined by thrombocytopaenia, hypofibrinogenaemia and elevated fibrin degradation products constitutes a major cause of severe haemorrhage and death in heatstroke victims

Anaemia

Trained athletes often have haemoglobin concentrations at the lower end of the normal range or below it Continual hard physical training also seems to produce a tendency to iron deficiency the serum ferritin concentrations of athletes tend to be low and they are likely to have reduced bone marrow iron stores [13] Various explanations have been proposed for these observations these include

—*haemolysis* a rapid and destructive turnover of red cells perhaps just from the mechanical trauma of pounding hard pavement Observations during a 750 mile relay race included a rise in plasma bilirubin and a fall in haptoglobin concentrations in a large number of the runners and although there was no significant fall in haemoglobin concentration this was taken as evidence for red cell haemolysis, presumed to be of mechanical origin [14] The reduction in serum ferritin concentration seen in some athletes has been explained by iron stores shifting from reticuloendothelial tissues to extramedullary sites especially in the liver Direct evidence of liver iron stores in athletes is not available to support this hypothesis but the shift is postulated to arise from hepatic uptake of haemoglobin-haptoglobin complexes formed during slightly increased intravascular red cell lysis in stressed tissues such as muscle and in the soles of pounding feet [11]

—*haematuria* the incidence of haematuria following prolonged strenuous and non traumatic exercise such as marathon running has been demonstrated to be high—13% in one study of subjects free of known renal disease and with normal pre-exercise urinalyses.[15] Running and other non contact sports (like swimming) may cause microscopic haematuria in the absence of direct renal trauma A common denominator is renal vasoconstriction This reduces the renal plasma flow rate to less than $\frac{1}{3}$ at a heart rate around 150–160 beats/min compared to resting levels The glomerular filtration fraction increases considerably during exercise (due to increased filtration pressure) This suggests a relatively more marked constriction of the efferent glomerular arteriole The distended glomerular vessels with a low blood flow rate, thereby increase their haemoglobin and albumin filtration Eventually the distension also allows passage of erythrocytes [16] Macroscopic haematuria is an infrequent occurrence after running Repeated trauma of the posterior bladder wall against the prostatic base is postulated as the mechanism of focal mucosal injury [15] Gross haematuria is also seen in classical march haematuria Rapid resolution is an important feature of post exercise haematuria whether macroscopic or microscopic

—*Inhibition of erythropoesis*

—*decreased iron absorption* during maximal exertion blood flow to the gut is reduced by up to 80% and although less marked in trained individuals remains sufficient to cause ischaemia Associated abdominal colic bloating, frequency and watery bowel movements may occur during rapid increases in training or races

—*Iron loss through sweating*

—*gastrointestinal blood loss* one recent study of 46 marathon runners found only a minor median increase in blood loss after the race equivalent to 0 4 ml of whole blood a day after the exclusion of results complicated by drug or dietary factors [7] Although this increase was statistically significant it was regarded as having no clinical relevance in healthy athletes More important however was the observation that this increase was significantly exaggerated in those who took drugs especially analgesics before the race. One subject who took aspirin and naproxen before running had a normal value for faecal occult blood before the race but a highly significant loss (13 08 mg Hb/g faeces) in the sample taken immediately after the race

(reference range 0 10 2 53 mg/g) The authors suggest on the basis of their findings that the use of drugs particularly analgesics by marathon runner should be actively discouraged Other workers have reported acute abdominal pain and bloody diarrhoea presumed to be caused by relative gut ischaemia in long distance runners and have cautioned that the entity may mimic acute appendicitis and Crohn s disease [12]

— *pseudoanaemia*" reflecting increased plasma volume [13 15]

In addition high adrenaline levels may increase both the osmotic and mechanical fragility of erythrocytes.

Many athletes with the relatively low haemoglobin concentration of 'pseudoanaemia' actually have a higher red cell mass per Kg body mass [15] It is argued that such a low haemoglobin is an optimal compromise between oxygen-carrying capacity and blood viscosity In addition oxygen availability per unit volume of blood is increased in athletes because of rises in 2 3 diphosphoglycerate concentration in the red cells As in prepubertal children this optimises oxygen transport from blood to the tissues The low haemoglobin concentration seen in athletes is thus frequently of no pathological significance and it has been suggested that athletes in training do not thus need any routine clinical or haematological monitoring or any iron supplementation [13] Other workers have reported that oral iron therapy (200 mg ferrous sulphate per day) normalised the haemoglobin concentration and improved the transferrin saturation fraction in competitive athletes found to have high transferrin iron binding capacity low serum iron and very low haptoglobin values [16] The authors further reported that following these improvements some of the distance runners reported personal (and national) records

PERSONAL OBSERVATIONS

The opportunity to participate in the 1987 London marathon enabled me to study the effect of the run on various of my own haematological parameters Although this was my first marathon I had undertaken a carefully planned four month training programme and believed myself to be adequately prepared The methodology results and comment are now presented

Venous blood was taken for analysis of total white cell count (WCC) differential white cell count haemoglobin concentration (Hb) haematocrit platelet count International Normalised Ratio (INR)—as a measure of the activity of the extrinsic pathway of coagulation Kaolin Cephalin Clotting Time (KCCT)—as a measure of the activity of the intrinsic pathway of coagulation fibrinogen titre fibrin degradation products (FDPs) and bilirubin concentration

The first sample was drawn 3 days before the race by which time training was minimal to give base line values A second sample was taken 1¼ hours after completion of the run which was at the earliest opportunity to be venesected A third sample was drawn 48 hours later

Urinalysis for macroscopic or microscopic haematuria haemoglobinuria and myoglobinuria was performed at the same time as the first and second blood samples

The results are shown in Table I

Even after accepting the simplicity of the study some observations can be made Perhaps the most interesting and indeed reassuring feature is that most of the parameters remained within their respective reference ranges. The two notable exceptions are the neutrophil count which demonstrated a five fold increase and the KCCT which was nearly 40% faster when measured 1½ hours after the run Both parameters had returned to normal by 48 hours These observations are consistent with those of the various workers whose studies have already been reviewed in this article

SUMMARY

The increase in popularity of long distance running that has occurred in recent years has made available large numbers of subjects for the investigation of the effects of prolonged physical exercise on many aspects of human physiology and metabolism The significance of the information thus obtained for service personnel particularly in the training environment is far from being of only academic interest

There are however broader implications for the results of such studies and examples can be seen even in the relatively narrow spectrum of the haematopathological factors discussed in this article The study of the response of lenkocytes to strenuous exercise may lead to a greater insight into the response of these cells to an infectious or inflammatory challenge In addition while the consequences of atherosclerosis in particular ischaemic heart disease remain the major cause of morbidity and

Table 1 Results of haematological investigations and urinalysis

Parameter	Reference range	Sample* 1	2		3
WCC × 10^9/L	3·6–9·2	5·8	24·0		6·2
Neutrophil count × 10^9/L	2·5–7·5	3·4	20·7		4·1
Lymphocyte count × 10^9/L	1·2–3·4	2·3	1·3		1·9
Hb g/dl	14–18	14·5	13·9		13·5
Haematocrit ratio	0·38–0·52	0·428	0·412		0·398
Platelet count × 10^9/L	140–440	311	312		278
INR	1·1·0	1·1·0	1·1·0		1·1·0
KCCT seconds (control)		39 (37)	24 (39)		38 (39)
FDPs	<10 μg/ml	<10 μg/ml	<10 μg/ml		†
Fibrinogen litre (control)		1 in 64 1 in 64	1 in 32 1 in 64	# #	1 in 32 1 in 64
Bilirubin μmol/L	<21	12	14		†
Haematinics		nil	nil		†
Haemoglobinuria		nil	nil		†
Myoglobinuria		nil	nil		†

* Samples 1 3 days before run (base line values)
2 1½ hours after run
3 48 hours after run

† Not tested

Difference in litre not considered significant for method employed

Personal data Age 28 years
Weight 64 Kg
Finishing time 2 hrs 58 mins 46 secs

mortality in the western world models for the study of platelet activation and interaction with the vascular endothelium yield information leading to a greater understanding of this condition. The implications for an increased understanding of the pathogenesis of atherosclerosis are obvious and extend far beyond the service horizon.

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Toe temperatures during Dartmoor training

S P L Travis

Abstract

The surface temperature of eight Royal Marine recruits was monitored in the field during Autumn training on Dartmoor (minimum air temperature 4·5°C). The lowest skin temperature recorded was 6·1°C. One subject experienced a toe temperature below 10° for 5·5 hours and below 15°C for 12·6 hours during a 24 hour recording period. Ambient temperature and inactivity during exposure to cold were the main factors associated with low toe temperatures but individual responses varied widely.

INTRODUCTION

COLD injury is a hazard to military operations in cold climates and remains a threat to peace time training.[1] Twenty eight per cent of the casualties during the 1982 Falklands conflict were due to cold injury,[2] most commonly affecting the feet, as were 27% of American casualties in the European winter of 1944–5.[3] Non-freezing cold injury is caused by prolonged exposure of the feet to cold wet conditions but the risk of injury cannot be predicted from ambient conditions alone because other variables such as activity, insulation and peripheral blood flow have to be considered.

Continuous toe temperature recordings provide a measure of the cold stress experienced by an individual in the field. Since ethical considerations prevent deliberate exposure of individuals to establish the duration of cold stress likely to cause cold injury, the toe temperature of individuals whose normal activities expose them to potentially damaging conditions has to be measured. The aim of this study was to document the peripheral skin temperatures commonly experienced by Royal Marine recruits during two 24 hour training periods in cold wet conditions.

METHODS

Subjects. Eight recruits from the Commando Training Centre Royal Marines, mean age 20 years (sd 1·07), volunteered to participate in the study. They had completed an average of 25·4 (sd 3·42) weeks of their 30 week training. Individuals with a past history of cold injury to the feet were excluded and ethical considerations in accordance with the Declaration of Helsinki were observed.

Environment. The two studies took place on Dartmoor in October at an altitude of 180–520 m. Air temperature, windspeed (measured with a hand held cup anemometer) and weather conditions are shown in *Table 1*.

Temperature measurement. Toe temperatures were recorded every 5 minutes. Thermistors (TH-U V2 tip diameter 2 mm, Grant Instruments, Cambridge) were taped to the medial side of the terminal phalanx of both big toes without encircling the toe. The thermistors could not be felt inside the boot. The leads were taped along the instep, posterior to the medial malleolus, up the leg and connected to a data logger (SQ2–44, Grant Instruments) carried at the waist. Air temperature was measured with a mercury thermometer 1 m from the ground. Thermistors and loggers were calibrated (5°–35°C ± 0·3°C) before and after the studies.

Clothing and equipment. Standard issue training dress was worn. This included loop-stitched combat socks (66% wool, 34% nylon), plastic mesh insoles and leather boots. New socks were

Surgeon Lt Cdr Travis recently completed a Short Service Commission and is now on the staff of St Thomas Hospital, London.

Table 1 Meteorological data

Study	Time of day	T_a (°C)	Windspeed (kts)	Observation
1	08–1800	8 0–12 5	0–11	Rain
	19–0700	10 0–11 0	0–5	Dry/drizzle
2	08–1800	7 5–8 5	4–22	Dry
	19–0700	4 5–6 5	0–4	Dry

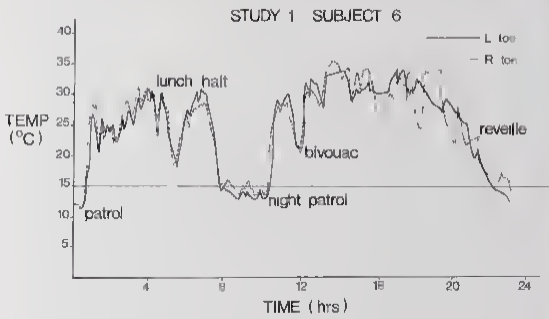

Fig 1 Toe temperature profile

issued twice daily and each boot was soaked in water when the socks were changed to ensure a standard degree of dampness. Weapons and equipment (total weight approximately 19 kg) were carried on patrols. Shelter at night was in a sleeping bag under a ground-sheet bivouac.

Studies: Both studies were part of a continuous 96 hour training period in the field. Each 24 hour study followed a similar pattern: after reveille at 0600 subjects were restricted to the bivouac area until a 24 km patrol at 0900. This involved open moorland walking and a knee deep river crossing after 45 mins. Subjects then remained in the bivouac area until a night patrol at 2000 in study 1 and a 4 hr static observation post in study 2 after which they entered sleeping bags. Timings of events were recorded by the author.

Statistical analysis: Toe temperature was plotted against time (*Figs* 1–2) and the information summarised in tabular form (*Tables* 2–3). The times of principal activities were marked on the graphs and the times spent with toe temperatures below 8° 10° and 15°C were measured from the graphs. Cumulative times have not been calculated where recordings below 15°C were intermittent. The duration spent with toe temperatures below 15°C in the two studies was compared by the Sign Test for binomial distribution.

RESULTS

Toe temperature profiles: Sample profiles are shown in *Figs* 1 and 2. These demonstrate the fluctuations of toe temperature that occur throughout the day in the field which clearly relate to different activities. The greatest range

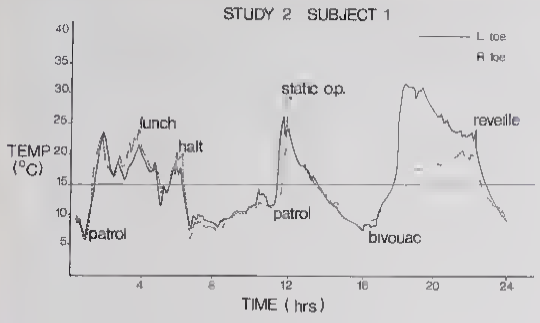

Fig 2 Toe temperature profile

of toe temperature in one individual was 26 1°C (10 0°–36 1°C subject 1 study 1)

Duration of low toe temperatures The cumulative times spent with toe temperatures below 15° and 10°C are shown in *Tables* 2 and 3 Subject 1 had a left toe temperature below 10°C for 5 5 hrs and below 15°C for 12 6 hrs during study 2 (*Fig* 2) Toe temperatures were below 15°C for significantly longer in study 2 ($p<0.02$) when ambient temperatures varied from 4 5° to 9 5°C compared with study 1 (8 0°–12 5°C) Intermittent recordings were caused by inadvertent removal of jack plugs and broken thermistor probes The percentage of total possible recordings is shown in *Tables* 2 3

Difference between right and left toe temperature The maximum simultaneous difference between toe temperatures in the same individual was 12 0°C in study 1 (subject 2) and 18 1°C in study 2 (subject 2) Comparable data was available from both sides in four subjects in study 1 and in another four subjects in study 2 The difference between the two sides ranged from 13–45% of the longest time spent below 15°C in study 1 and 5 73% in study 2

Activities Exposure to cold caused a fall in toe temperature within minutes but there was marked individual variation which appeared to depend on the initial toe temperature Static activities (such as lying in an observation post *Fig* 2) caused the most consistent cooling Rewarming generated by exercise or entering the bivouac was less predictable and delays in rewarming of 10–25 mins were not uncommon between the right and left toes of the same individual (*Fig* 2) The effect of foot immersion (during the river crossing at 0945 in both studies) was offset by continued exercise

Minimum toe temperatures Tables 2–3 show the minimum toe temperatures (T_{min}) recorded in all subjects The minimum toe temperature recorded was 6 1°C in both feet of subject 1 study 2 at 0900 prior to the start of the patrol

DISCUSSION

This study demonstrates that the surface toe temperatures of Royal Marine recruits may remain below 15°C for many hours during training on Dartmoor in relatively mild conditions Toe temperatures below 10°C were common and one subject had a right toe temperature below 8°C for 85 minutes during study 2 The lowest toe temperature recorded was 6 1°C

The principal differences between the two studies were the ambient temperature and the duration of inactivity As a result of the lower ambient temperature in study 2 (*Table* 1) with

Table 2 Study 1 toe temperature data

Subject		Time <15°C (hrs)	% Recordings	T_{min} (°C)
1	R	4 3	80	10 9
	L	—	35	—
2	R	1 5	96	10 3
	L	2 6	100	11 4
3	R	3 9	100	10 0
	L	—	30	—
4	R	—	32	—
	L	1 9	100	11 2
5	R	3 8	100	11 2
	L	3 1	100	10 9
6	R	2 3	100	11 4
	L	4 0	100	11 4
7	R	3 8	100	12 0
	L	2 8	94	12 9
8	R	—	29	—
	L	—	33	—

Cumulative time toe temperature remained below 15°C, percentage of total recordings (n=275) and minimum toe temperature

Table 3 Toe temperature data

Subject		Time <8 (hrs)	Time <10° (hrs)	Time <15° (hrs)	% Recordings	T_{min} (°C)
1	R	1 4	4 6	13 2	100	6 1
	L	0 8	5 5	12 6	100	6 1
2	R	0	0	2 3	100	12 3
	L	0	0	8 9	100	10 3
3	R	0	0 1	7 1	87	9 5
	L	—	—	—	7	—
4	R	—	—	—	32	—
	L	0 4	1 8	11 7	85	7 5
5	R	—	—	—	10	—
	L	—	—	—	10	—
6	R	0	0	6 7	93	12 0
	L	—	—	—	82	—
7	R	0	1 2	10 0	100	8 6
	L	0	0 2	8 4	98	9 5
8	R	0	0	4 7	100	11 2
	L	0	0 5	8 1	99	9 5

Cumulative time toe temperatures remained below 8°, 10° and 15°C, percentage of total recordings (n=275) and minimum toe temperature

the 4 hour nocturnal observation post, toe temperatures were below 15°C for significantly longer than in study 1 ($p<0.02$). Inactivity during exposure to cold precipitated a drop in toe temperature within minutes which meant that the main periods at risk of a low toe temperature were in the morning after getting out of the bivouac after exercise or during observation posts. Even a stop of 20 mins during a patrol caused an appreciable fall in toe temperature (eg 7.2°C Fig 1 4.8 hrs).

Variation between individuals was marked and unpredictable with different responses to similar stimuli. For instance some subjects showed rapid rewarming upon getting into their bivouac whilst others showed very little response. Delays in rewarming of 10–25 minutes were common between the sides of the same individual but a similar degree of variation has been observed under controlled conditions.[4] The reasons for this are several: the skin temperature of digits depends on local blood flow which in turn depends on ambient temperature, core temperature, mean skin temperature, psychological factors such as stress,[5] hydration and blood viscosity.[6] The maximum simultaneous difference between right and left toe temperatures of 18.1°C (subject 1, study 2) is less easy to explain in an active subject. A difference of 10°C occurred too commonly to be attributed to one foot being wetter than the other. Both friction and local control of blood flow may have contributed.

Profound physiological changes occur to nerves and membranes below 10°C. Conduction velocity in somatic nerves decreases below 25°C and is blocked in group II fibres after 5 mins at 10°C.[7] This block is reversible on rewarming although neuronal degeneration may occur after longer periods of cooling. The sensation of numbness corresponds to skin receptor desensitisation[8] and may be related to inhibition of neurotransmitter release below 7°C.[9] To the author's knowledge these are the first reported observations of toe temperatures measured in cold, wet conditions in the field. The degree of variation precluded further statistical analysis but this does not detract from the observations which document the actual peripheral temperatures experienced by recruits during Autumn training on Dartmoor. The main message is that very low toe temperatures occur even in fairly mild conditions. If non-freezing cold injury is to be prevented then the time spent with low toe temperatures has to be reduced by improving the insulation of foot wear. The critical temperature or duration of low temperature that produces cold injury remains unknown.

ACKNOWLEDGEMENTS

This study would not have possible without the help of the Department of Survival Medicine, Institute of Naval Medicine. Surg. Capt. F. Golden OBE RN, Lt. Cdr. (MS) M. Wagstaff RN, POMA S. Cooper and other members of the Medical Department of CTCRM. The permission of the Commanding Officer CTCRM and the cheerful cooperation of the recruits under the direction of Lt. P. Holdom RM was appreciated.

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J roy nav med Serv 1988 74 187–194

A description of the outbreak of meningitis in HMS *Raleigh* in February 1987

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Abstract

This paper describes an outbreak of meningococcal meningitis at HMS *Raleigh* in February 1987 and the action taken to control it

The three cases all responded to conventional penicillin therapy and returned to duty Meningococcal naso-pharyngeal carriage rates of up to 62% were recorded during the outbreak The poor compliance with rifampicin prophylaxis the emergence of resistant strains and the use and effectiveness of ciprofloxacin are described Recommendations are made on some aspects of the management of similar outbreaks.

INTRODUCTION

MENINGOCOCCAL Meningitis has long been associated with institutions such as schools and particularly with military recruit training establishments where immunologically naive young men are living close together for prolonged periods and may be subjected to additional stresses such as cold exhaustion and other infections [1] Overcrowding was identified as a major remediable cause of the disease by the Medical Research Committee investigating the 1915 outbreak of Cerebrospinal Fever (meningococcal meningitis) and following their recommendations the Army laid down minimum floor space and air volumes per man in barrack blocks

Between the two World Wars this was fixed at 5·7 sq metres (60 sq ft) and 17 cu metres (600 cu ft) of air space per man but following the outbreak of war this was progressively reduced declining to 2·8 sq metres (30 sq ft) and 8·5 cu metres (300 cu ft) in 1942 [2] Current PSA standards for new buildings are 8·5 sq metres (90 sq ft) and 20·4 cu metres (720 cu ft) coupled with a ventilation rate of 2 air changes per hour or 'adequate natural ventilation Observation suggests that in cold weather windows tend to remain closed and in modern accommodation with well sealed windows this level of air movement is improbable unless artificial ventilation is fitted.

In the UK, Cerebrospinal Fever was made statutorily notifiable in 1912 and there have been five defineable national epidemics since though the picture is dominated and possibly distorted by the major outbreaks that occurred during the two World Wars [3] In Norway there have been four major epidemics at roughly 30 year intervals over the last century Sweden relatively unaffected by war experienced four major epidemics between 1880 and 1917 with only minor fluctuations since Many North African and sub Saharan countries show a roughly 10 yearly cycle of epidemics [4]

The highest incidence of meningococcal meningitis in the UK is in the winter [1] In Africa, where meningococcal meningitis is endemic between the 300 mm and 1100 mm rainfall lines epidemics usually occur at the end of the dry season in March and April whereas in Scandinavia the seasonal influence is less clear [4] The cause of this seasonal variation is not known but overcrowding, restricted ventilation and respiratory infections have been incriminated [1,5]

The UK mortality rate in meningococcal meningitis is highest in the very young, 55% of

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cases occurring in children aged less than 5 years[3,4] and the disease causes 2% of all deaths of children aged between 1 and 4 years.[5] Prior to the introduction of effective treatment the overall mortality rate ranged from 50–80%[4]. Serotherapy was introduced in 1907 with a fall in mortality to 14–25%[4] though the figure in the UK from 1914–1916 was about 60%. Sulphonamides reduced the mortality to 5–12%[4] and the introduction of penicillin in 1943 further reduced the mortality rate to 2–10%.[4,6] The present mortality rate in the UK is about 10%.[7]

Nasopharyngeal carriage of N meningitidis is common being high in younger age groups and those living in close contact with others and relatively low in older people. In a study at HMS *Ganges*[8] in the absence of an outbreak the carriage rate of N meningitidis (all groups) among the new entry was 30% rising to 45% after three months and 71% after nine months of training and in a group examined on all three occasions 87% had harboured the organism at some time. In US Army recruits a 33% carriage rate was found on entry rising to 80% after six weeks in the absence of an outbreak.[8] During an outbreak the proportion of meningococci of the outbreak strain will normally rise but this is very variable and may be as low as 0.5% or as high as 90% of meningococci isolated.[6]

Meningococci are divided into groups according to the antigenic properties of their cell wall polysaccharides. Eight main groups are recognised A, B, C, X, Y, Z, W135 and 29E and these groups are further sub divided or typed according to the antigenic properties of the outer membrane protein. Groups A, B and C account for at least 90% of all meningococcal disease.[4]

HMS *Raleigh* is a large establishment handling all RN and RNR ratings basic training and a number of other courses—firefighting being an example. It also hosts a number of visits from Sea Cadet Units, Girls Nautical Training Corps etc and attracts a large number of visitors. There are 684 RN permanent staff, 98 civilian employees and the number of trainees varies from around 1 200 up to 2 400. Normally *Raleigh* takes in a fresh group of about 150 trainees each week and a similar number join for shorter courses.

Those on short courses live in separate blocks to the main body of trainees, and trainees in their first week are also segregated. After the first week trainees are divided into classes of about 25. A class will share a dormitory and attend classroom and practical training together and will to some extent remain as a discrete group within *Raleigh*. All trainees share a single dining hall and NAAFI and there is also mixing of groups for some lectures, sport, PT, Parade Training, Church and Sick parades and in shared heads and bathrooms.

Trainees are not allowed to go ashore until their penultimate weekend—the fifth out of six in most cases though some 25% of trainees are on longer courses. Those on short courses are free most evenings and the majority of staff live ashore.

METHOD

Meningococcal carriage was determined by examination of posterior pharyngeal swabs taken by medical and nursing staff instructed in the correct technique. Dry cotton wool swabs were used to sample the posterior wall of the pharynx and were plated directly on to a selective medium (heated blood agar with vancomycin, colistin and trimethoprim) in the medical centre by staff from the Plymouth Public Health Laboratory (PHL). The plates were returned to the PHL and incubated at 37°C in 5% CO_2 in air for 48 hours. Plates were examined at 24 and 48 hours for the presence of meningococci.

All meningococci were serogrouped in the PHL using antisera to groups A, B, C and Y. Confirmation of the grouping, Frasch typing and antibiotic sensitivity were determined at the Meningococcal Reference Laboratory, Manchester.

THE COURSE OF THE OUTBREAK, RESULTS AND MANAGEMENT

The first case, a 16 year old male who had joined *Raleigh* on 26 January, presented on 12 February with pyrexia, headache and a sore throat. He became disorientated and developed neck stiffness during the day and was transferred to RN Hospital Plymouth that evening with a clinical diagnosis of meningococcal meningitis. The diagnosis was confirmed late on 14 February when N meningitidis was isolated from CSF.

The second case, a male aged 17, presented with similar symptoms on 17 February and the third, a male aged 18, the following day. Both were admitted to RN Hospital Plymouth. These two cases had joined *Raleigh* on 2 February and were in the same dormitory. They were one training week behind the first case, with whom

no clear epidemiological link could be established In none of the three cases was there a rash or arthritis All responded to conventional penicillin therapy and subsequently returned to training

Service authorities and District Community Physicians were informed, and, in accordance with a research protocol currently being followed in Plymouth[4] posterior pharyngeal swabs were taken from all dormitory and close sick bay contacts all of whom were then given rifampicin 600 mg bd for two days Medical and nursing contacts of the first case were given rifampicin prophylaxis though this is not normally considered necessary[10] and was not given in subsequent cases

By 20 February the meningococci from the three cases had been grouped and typed All were group C type 2b sensitive to rifampicin and penicillin Preliminary swab results from the 55 dormitory contacts were available meningococci had been isolated from 34 (62%) and of these 24 (44%) were strains of N meningitidis indistinguishable from the outbreak strain

A co ordinating team was defined and a meeting was held on 20 February involving the Consultant medical microbiologists of the PHL in Plymouth PMO *Raleigh* District Community Physicians and NMOH to agree plans to handle the outbreak The DHSS the Communicable Disease Surveillance Centre (CDSC) the Meningococcal Reference Laboratory Manchester and the RN Adviser in Pathology were consulted Factors which were considered particularly important were the high prevalence of pharyngeal carriage of the outbreak strain among the close contacts of the three cases (44%) the availability of a vaccine against group C meningococci the often demonstrated speed with which the disease can spread in military training establishments and the risk of spreading the disease to other receptive areas particularly the tightly packed messes of ships and submarines The agreed essentials of management were as follows

a Trainees leaving *Raleigh* on 20/21 February were to have a pharyngeal swab taken to assess the prevalence of meningococcal carriage outside the group of close contacts and all would be given rifampicin prophylaxis All trainees leaving subsequently were to have pharyngeal swabs taken during their final week and only those shown to be carrying meningococci were to be given rifampicin All were to have pharyngeal swabs repeated 4 days later in their receiving units

b All personnel in the establishment were to have pharyngeal swabs taken on 23/24 February and rifampicin prophylaxis would be given to all carriers who would have a repeat pharyngeal swab taken 4 days later

c Families of permanent staff shown to be meningococcal carriers would be advised to have rifampicin prophylaxis at the same time which would be explained in a letter to their general practitioners and obtained from NHS sources

d Combined group A and C polysaccharide vaccine would be given initially to the new entry joining on 23 February and as more vaccine became available from the manufacturer in France the whole establishment would be vaccinated

e With the use of rifampicin to eradicate pharyngeal carriage and the protection of the new entry by vaccine it was considered that there was no requirement to stop leave prevent new entry joining or trained men from leaving to join other ships Training could continue and families could continue to attend passing out parades

f Press enquiries would be dealt with by Flag Officer Plymouth s Press Officer

g Additional staff would be made available to *Raleigh* by the PHLS RN Hospital Plymouth ships in harbour and the NMOH s team

h MOD(DMSD) was contacted approval was gained for the proposed action and financial approval was obtained for the expense of drugs and vaccines

i A signal was sent to those involved describing the actions to be taken and defining responsibilities

Over the next week this programme was carried out and there were no further cases

A second meeting of the Co ordination Team was held on 3 March to review progress 2 476 people had been swabbed. Meningococci had been isolated from 916 (37%) of cases 416 (17%) were group C and indistinguishable from the outbreak strain The division of the swabbed population into trainees permanent staff and civilian employees and the further division of the Trainees into classes remained to be done but it appeared that the prevalence of group C meningococci might be as high as 40% among Trainees and lower in the other groups The whole population of *Raleigh* (2 214) had attended the Medical Centre on 2

aad 3 March for vaccination with the polysaccharide A and C vaccine and prior to the meeting it had been agreed that pharyngeal swabs would be taken during this visit to assess the overall efficacy of control measures Rifampicin had successfully eradicated meningococci from the pharynx of 90% of the close contacts and the side effects reported from the drug had been minimal

It was decided to continue to use rifampicin prophylaxis Trainees would continue to have pharyngeal swabs taken during their final week and rifampicin would be given to those shown to be carrying meningococci Vaccination of the new entry would continue until 6 April the last entry of the Spring term

During the week beginning on 15 March various disturbing developments began to appear Analysis of swab results showed that over a week approximately 10% of those previously negative had acquired the organism Rifampicin had failed to eradicate meningococci in 27% of recipients, and in 5% of these a rifampicin resistant strain was found after therapy Enquiries suggested a failure of compliance in at least 25% of trainees The prevalence of meningococcal carriage in *Raleigh* remained at 19% with evidence of continuing transmission of the outbreak strain

The Co-ordinating Team considered that the policy of treating only the identified nasopharyngeal carriers with rifampicin had failed and that to interrupt transmission and control the outbreak it was essential to treat the whole population of *Raleigh* simultaneously A single dose antibiotic which could be taken orally in the Sick Bay under supervision would ensure good compliance and it was desirable that there should be little prospect of drug resistance either present before treatment or developing as a result of it Ciprofloxacin in a single oral dose of 500 mg matched the requirement and was recommended Families and close civilian contacts of those carrying the outbreak strain were given letters for their general practitioners recommending sulphadimidine prophylaxis DMSD approval for this treatment was given on 27 March and the whole establishment was treated and pharyngeal swabs taken on 30 and 31 March.

Follow up pharyngeal swabs were taken 4 days after ciprofloxacin treatment from 336 previously positive cases and as a check on reinfection rates pharyngeal swabs were taken from 234 previously negative Trainees Meningococci indistinguishable from those isolated prior to ciprofloxacin treatment were isolated in 13 cases giving a success rate of 96% and it has been established that 3 of these failures did not take the drug There was one acquisition

At the end of the spring term the prevalence of meningococcal carriage in *Raleigh* was estimated to be approximately 1% and control measures were discontinued

DISCUSSION

The appointment of a manager or management team is an important and well established first step in the control of any significant outbreak of infectious disease The team in this outbreak was chaired by the Director of the Plymouth PHL and included the members shown below with their respective main responsibilities

a The PMO of HMS *Raleigh* Responsible for the implementation of all health control measures within *Raleigh* and advising the management team on all aspects of training within *Raleigh* so that the investigation and control measures proposed would cause the minimum of disruption

b The Consultant Medical Microbiologists from the Plymouth PHL Responsible with the Director of the PHL for the provision of staff from the PHL to carry out plating on site at *Raleigh* and for the huge volume of culturing grouping data recording and analysis undertaken in the PHL They provided bacteriological information initiated and maintained contact with civilian experts and interpreted the advice received.

c The Naval Medical Officer of Health Responsible for keeping service authorities informed of all aspects of the outbreak consulting with service advisors obtaining medical and financial approval for the control measures and ensuring that the necessary drugs and vaccines were available

d The District Medical Officers of Cornwall and Plymouth Both were necessary because of the position of *Raleigh* in Cornwall but in a Plymouth dormitory area They were responsible for all liaison with local General Practitioners and local government in addition to their statutory responsibility for the control of infectious disease.

The team which was known as the Co ordinating Team in this outbreak was responsible for all management decisions subject to the approval of the DHSS and MOD Advice was sought from the DHSS the Communicable Disease Surveillance Centre at Colindale the

RN Advisor in Pathology and the Meningococcal Reference Laboratory Manchester who also confirmed grouping and typed all meningococci isolated in the PHL Plymouth.

At the first meeting of the Co-ordinating Team on 20 February the selection and employment of prophylaxis was discussed. Rifampicin had been given to the dormitory contacts of the three cases without waiting for the results of pharyngeal swabs in accordance with established recommendations. Meningococci isolated from the three cases had been shown to be sensitive to penicillin and rifampicin but the sensitivity to sulphonamides which was being determined in the Meningococcal Reference Laboratory was still unknown. In view of the strong probability of sulphonamide resistance and current recommendations on prophylaxis in the UK it was decided to use rifampicin.

At this early stage of the outbreak the nasopharyngeal carriage rate of the outbreak strain among the dormitory contacts of the cases was known (44%) but pharyngeal swabs had not been taken from other recruits of the permanent staff. Meningitis had developed in two groups of recruits with only a weak epidemiological link and experience of previous outbreaks suggested that the carriage rate was likely to be high across the whole population of *Raleigh*. If this was confirmed there would be two reasons to extend the use of rifampicin prophylaxis

a To prevent transmission of the organism to other ships or establishments and to civilian contacts. This was the reason for the treatment of recruits leaving *Raleigh* and the tracing and treatment of families of permanent staff found to be carrying the organism.

b To protect those with no natural immunity. Though vaccine was to be given there would be a delay of up to 7 days before this was available and a further 5 days would elapse before any significant immunity developed.

There were also two possible approaches to the employment of prophylaxis

a To treat the whole population of *Raleigh*. This was proposed by the Co-ordinating Team because it appeared to offer the best chance of stopping transmission could be instituted as soon as swabs from a representative sample of the population demonstrated a high carriage rate and would involve less administrative work, but expert advice was that it was likely to give rise to rifampicin resistant meningococci and tubercle bacilli and it was not recommended.

b To treat only those found to be nasopharyngeal carriers—the hunt and kill approach. This would involve rather more delay before prophylaxis was complete because of the time required to culture pharyngeal swabs from the whole population of *Raleigh* and would involve more administrative work, but was recommended by the experts because it had been successful in the control of outbreaks of meningococcal disease in the community and this approach was therefore adopted.

The use of rifampicin in this outbreak on a hunt and kill basis failed to halt transmission of the outbreak strain or to reduce the carriage rate to an acceptable level. Several factors contributed to this failure.

a Non Compliance. It is difficult to collect accurate information on compliance because trainees are reluctant to admit that they have not carried out instructions. A subjective assessment based on interviews with a cross section of trainees is that about 25% did not complete the rifampicin therapy.

b Rifampicin Resistance. In common with experience in other outbreaks [11, 12] resistant meningococci were found in 5% of treatment failures.

c Acquisition after swabbing. The hunt and kill approach with the unavoidable delay of 2–3 days between swabbing and the commencement of prophylaxis resulted in a number of carriers being free within the establishment and able to pass the infection on to others.

d Acquisition Rate. High acquisition rates are features of outbreaks due to groups A and C meningococci. In this outbreak a weekly acquisition rate of approximately 10% was demonstrated over the period when rifampicin was being used on a large scale.

As a result of this failure there was a need to review management and in particular to reconsider the merits of giving an antibiotic to the whole population at the same time. The ideal antibiotic for this purpose would be effective with a single dose to ensure good compliance, would not induce drug resistance, be well tolerated and be of reasonable cost. Ciprofloxacin a recently introduced 4 quinolone antibiotic with few reported side effects[13] appeared suitable. It has been successfully used in doses of 250 to 500 mg twice daily to eradicate

pharyngeal carriage of meningococci [14, 3] and as a single dose of 250 mg in the treatment of genital gonorrhoea [16] No significant side effects were encountered in any of these trials In view of the similar minimum inhibitory concentrations of ciprofloxacin to N gonorrhoeae and N meningitidis and the low incidence of side effects it was decided to use a single dose of 500 mg which could be given under supervision to ensure compliance This was successful in 96% of recipients and confirms that ciprofloxacin is useful in the management of outbreaks of meningococcal disease [17]

The need to use vaccine in this outbreak was questioned when only three cases occurred There is abundant evidence that meningitis can spread rapidly in communities such as schools and military establishments [1 10] Peltola[4] has given unequivocal advice that where there are signs of a group A or group C epidemic a large scale vaccination programme should be undertaken without hesitation Indeed with a mortality rate of around 10% it would be unethical not to offer vaccination Vaccination was offered first to the new entry because as a group they were less likely to have acquired any natural immunity to meningococci than those who had been in the establishment longer The Ministry of Defence is currently reviewing the policy on the vaccination of new entrants against meningococcal meningitis

When the programme of pharyngeal swabbing was initiated there was little information available on the rate at which patients could be processed the number of staff required or on the best method of record keeping Experience showed that with two staff taking swabs and three laboratory technicians plating, it was possible to work comfortably at a rate of three patients a minute for prolonged periods Patients had their names recorded in manuscript as they entered the Medical Centre and were allocated a number which was used to identify plates This simple system was basically sound but problems were caused because handwriting could not be deciphered and many patients forgot their numbers It is recommended that a typist should be used for recording in preference to manuscript entries and that each patient should be given his number on a piece of paper

The Press Radio and Television were in general understanding and helpful but certain local papers sought to sensationalise the outbreak principally on the grounds of a perceived risk to the local population These articles published in the first week of March produced a deluge of enquiries from worried local residents and their GPs to District Medical Officers in both Cornwall and Plymouth and a large number of press enquiries to Flag Officer Plymouth s Press Officer who was hard pressed to answer questions on civilian health This mild local hysteria was eventually calmed after television appearances by the Cornwall District Medical Officer and an agreed joint press release by Plymouth and Cornwall District Medical Officers and the Royal Navy In retrospect, the decision to refer all press enquiries on the outbreak to a Royal Navy press officer was probably wrong in the eyes of the press he had neither the knowledge nor the credibility to handle the civilian aspects of the outbreak and the traditional defensive attitude of MOD Press Officers encouraged the Press to embroider any information that was released It is considered that a joint press liaison exercise between the Royal Navy and the District Health Authorities would have achieved the early resolution of problems more effectively and that the Royal Navy and Health Authority Public Relations Officers should have been more closely involved with the Co ordinating Team from the start of the outbreak

Bed spacing air space and ventilation were checked early in the outbreak and at 5 8 sq metres (63 sq ft) and 16 5 cu metres (580 sq ft) were roughly in line with the Army recommendations of the inter war years though below present standards The ventilation was studied on a blustery day with two windows open and found to be adequate with four air changes per hour With the windows closed there was no detectable air movement and this is an aspect that should be considered in any future outbreak

CONCLUSIONS AND RECOMMENDATIONS

a A management team with representatives from all authorities involved should be appointed in any significant outbreak of infectious disease The team chosen in this outbreak worked well though the absence of the Public Relations Officer from early meetings was unfortunate

b Vaccination should be offered as early as possible in any outbreak of group A or C meningococcal disease

c. The policy of giving rifampicin prophylaxis only to nasopharyngeal carriers was probably inappropriate It is recommended that in the closed environment of a military

training establishment chemoprophylaxis needs to be introduced early and should encompass all staff and trainees without awaiting the results of swabbing

d Rifampicin was not successful in halting transmission because of the emergence of resistant strains the poor compliance and the policy of treating only the carriers An effective single dose antibiotic such as ciprofloxacin is preferable

e Overcrowding and poor ventilation of dormitories classrooms and other accommodation are time honoured factors in meningococcal meningitis which should be examined checked and corrected routinely and early in any outbreak

f Public Relations Officers should be involved from the onset in any such outbreaks of infectious disease Where the outbreak occurs in a Service environment the Service and civilian Public Relations Officers should work together

g The illegible handwriting on records and patients who forgot numbers caused delay and extra work A typist should be used for the preparation of nominal lists and patients should be given numbered tickets or cards.

ACKNOWLEDGEMENT

The authors are most grateful to the staff of the Plymouth Public Health Laboratory and the sickbay at HMS *Raleigh* and in particular to Surgeon Lieutenant Commanders R G Jones and C J McArthur for their work during this outbreak.

Editor s Footnote

The bacteriological and serological aspects of this outbreak of meningococcal meningitis will be described more fully in forthcoming papers

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J roy nav med Serv 1968 74 195–198

Poisonous fish and seasnakes in the Arabian Gulf

G L Greenslade and M Furnell

SUMMARY

A case history is given followed by a discussion of the management of seasnake bites and poisonous fish stings with guidance on differentiating between the two types of injury

CASE HISTORY

A 24 year old Able Seaman presented with a recurrence of infection at the site of a catfish sting sustained on the lateral aspect of the right calf The original injury had occurred three months previously when he caught a catfish whilst fishing in the Arabian Gulf The distinctive fish stung him causing intense pain in the vicinity of the wound which was treated with soluble aspirin and elevation of the limb The pain disabled him for two days Four days later the wound became infected his temperature was raised slightly at 37 3 C The 2 mm diameter puncture wound had healed over but there was lymphadenopathy of the inguinal nodes on the affected side Antibiotic therapy was started with intravenous (IV) benzylpenicillin and metronidazole. He became apyrexial six hours after starting therapy and the local inflammation began to subside He was returned to his ship and remained on this treatment for 48 hours when he was switched to oral treatment with phenoxymethylpenicillin 500 mg six hourly and metronidazole 400 mg eight hourly

On this therapy the patient relapsed and was admitted to the sickbay of the Royal Fleet Auxiliary *Diligence* The wound was leaking sero-sanguinous fluid and there was brawny oedema around the wound A wound swab was taken (but it proved impossible to enlarge it due to the time taken to get the swab to a microbiological laboratory) and the patient commenced on cefuroxime 750 mg IV eight-hourly The infection settled rapidly on this regime and he was discharged fit for duty after five days

Ten weeks later he presented to HMS *Hermaid*'s sickbay with an abscess at the site of the sting. He was apyrexial and there was no lymphadenopathy The abscess was incised and drained yielding five millilitres of pus Gentle probing revealed a subcutaneous sinus running some six centimetres distally to the incision site This sinus was laid open (*Fig* 1) and it was during this procedure that some grittiness was noted in the base of the wound Initially the cause was not apparent but probing revealed a barbed fish spine which was freed by sharp dissection (*Fig* 2) Plain paraffin gauze was laid in the wound which was dressed daily for five days Twenty eight days later the wound had healed by secondary intention with an acceptable cosmetic result

DISCUSSION

Venomous fish have bony spines covered by venom-secreting tissues Catfish belong to the *Siluroidei* suborder and are mostly riverine but sometimes coastal in their distribution They have barbed spines and whiskery mouthpieces

The main feature of venomous fish stings is intense pain which without effective treatment lasts for about two days The spines frequently break off and are left embedded in the victim's tissues resulting in a chronic foreign body

Surgeon Lieutenant Greenslade is serving in HMS *Herald* LMA Furnell is serving in RNH Plymouth

Table Features aiding differentiation between sea snake bite and venomous fish stings

Venomous Fish	Sea snakes
Local pain, inflammation and swelling	*NO* local effects from poisoning
Systemic effects rare	25% of victims have systemic features of envenomation viz
Death very rare	1 Generalised muscle aches pains and stiffness on movement developing one half to one hour after the bite
	2 Moderate to severe pain on *passive* movement of arm thigh neck or trunk muscles developing one to two hours after the bite †
	3 Myoglobinuria evident three to six hours after the bite A dusky yellowness with positive urinalysis for blood and protein precedes the reddish tinge of myoglobinuria by about an hour
	4 Natural mortality 10% Average death time 15 hours *

† *If after one hour the bite has not produced muscle pain on active movement severe poisoning can be excluded*

* *Ptosis weakness of extrinsic ocular muscles pupillary dilatation with sluggish light reaction and leucocytosis > 20 000 cells/mm³ indicates severe poisoning for which 3 or 4 ampoules of antivenom should be administered*

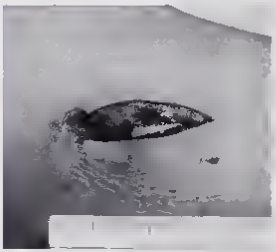

Fig 1 Incised abscess cavity seen to communicate with the sinus which has been laid open The fish sting is seen in the base of the wound after having been dissected-out

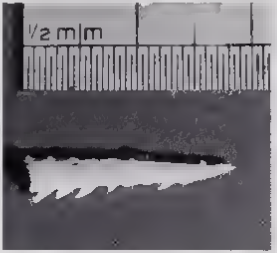

Fig 2 Spine removed from the wound some three months after the initial injury

reaction Death is unusual although two fatalities have been attributed to stonefish stings [1]

In the case described retention of the catfish spine lead to chronic suppuration and sinus formation It is interesting that after settling initially on IV benzylpenicillin the infection relapsed on the oral therapy Probably this was due to the unpredictable absorption of phenoxymethylpenicillin which shows considerable intersubject variation and intrasubject unpredictability due to such variables as changes in gastric acidity and the timing of the dose in relation to the ingestion of food [2]

Recommendations for the treatment of venomous fish stings are as follows [1] The affected

part should if possible be immersed in water as hot as *the patient* can tolerate (usually 50 degrees C or above). As soon as the pain has subsided the part is removed from the water to prevent blistering due to the heat. When the pain returns the part is reimmersed until relief is regained then removed again. The water must be replenished throughout the procedure to ensure that it remains hot. If allowed to cool down the water will lose its effect. After about 30 minutes of this process the pain will no longer return and the treatment may be discontinued. Parts of the body not amenable to such immersion may be treated (less effectively) by local infiltration with plain lignocaine 1%. Local nerve block using 0.5% bupivicaine has been found to be preferable by one author.[3] In the uncommon event of a fish sting causing severe systemic effects subcutaneous adrenaline for hypotension and atropine for bradycardia may be required along with appropriate supportive therapy. A specific antivenom is produced for stonefish stings. One author recommends the routine exploration of these injuries to exclude the presence of retained fish spines and the administration of a course of broad-spectrum antibiotics.[4] The case reported on here suggests that this might be a prudent policy.

Seasnakes inhabit coastal waters. The systemic effects of their bites are due to nerve and muscle cell toxins.[3] Although less common than venomous fish stings their bites are more likely to prove fatal. A quarter of those bitten are seriously envenomed and need treatment with antivenom which is derived from horse serum.[4] This is effective in severe poisoning, even when given seven or eight hours after the bite. Its use is associated with a significant incidence of anaphylactic reactions (due to its equine origins) so that its use should be confined to cases of confirmed seasnake envenomation. All patients selected for treatment should be pre-treated with IV antihistamines and subcutaneous adrenaline. Patients with a history of atopy should receive IV hydrocortisone in addition. The antivenom is best given diluted in Hartmann's solution of N saline (one part to ten of diluent) as a slow IV infusion. These details are fully covered in the helpful data sheet supplied with the antivenom. Clinical features that will aid in differentiating between seasnake bites and fish stings are given in the *Table*.

ACKNOWLEDGEMENTS

The authors wish to thank Dr A. P. Fowler, Senior Medical Officer of the Royal Fleet Auxiliary *Dhrgence* for his assistance in the preparation of this report and Leading Airman (Photographer) P. McCabe for the excellent photographs of the case.

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BOOK REVIEWS

Human Behaviour in Illness Lynn Gillis MD FRCPsych DPM Fourth Edition

This book is aimed at all those caring agents be they qnote Medical Nursing, Dental Social Workers Occupational Therapists Physiotherapists, and ancillary workers It is therefore appropriate that it takes the widest common denominator and gives only basic information In consequence many of its valuable sections have been heavily edited

The objects of the book are to

1 Assist workers in dealing with the human problems of sick people

2 To increase awareness and understanding, provide information about human relations in a non technical level

3 It hopes to develop a level of self-awareness

The literary style makes it easy reading enforcing the reader to examine personal attitudes sets in order to ensure that as a caring agent they treat the person as a unique individual using self awareness as a basis on which to identify and show empathy

The Author s introduction into the many models of care assumed much of the reader regarding previous knowledge base It is unfortunate that some examples given show a tendency towards valued judgements and stereotyping

I liked the caring almost alertive nature of areas covering.

(a) Burn out a growing problem within the caring professions and

(b) The handling of death, its affects on not only the patient and relatives but also on the professional carer and the need to recognise their own needs at this time.

A reasonable overview of major psychiatric conditions is given I was disappointed with the comments on individual professional roles which it does not reflect the vast changes which are occurring at an almost daily pace reflecting either professional overlap or variety of skills on which treatment is based today

Although the book claims to have been completely revised not all out of date material has been removed ECT and Lobotomy are far too casually discussed and by implication still common practice These highly select procedures full list of places and book of this basic introductory nature

The inclusion of bandage rolling as an occupational activity is grossly out of date. These factors weaken the other factual content

The set questions intended for individual work or group discussion are all very interesting. Many will require further exploratory reading outside this text but they should stimulate further interest in our fellow man

I liked the manner in which the need to challenge one s personal attitudes are aired an important factor when considering the way in which interpersonal relationships are conducted and and that the need to ensure equal understanding is essential for good patient care

The book achieved its basic aims I would encourage its use as precourse reading for those in the early stages of their career

JDB

ABC of Alcohol. Ed Alex Paton Pp 35 British Medical Journal 1988 Inland £5 95 Abroad £7 50 USA $13 00

In this second edition Richard Smith provides in the Introduction a catalogue of statistics which amply demonstrate the impact of alcohol related problems (It is estimated for example that alcohol accounts for between a fifth and a third of medical admissions to hospital) and states the case for action to reduce this burden

That the importance of this case case was recognised by the Editor is demonstrated by the fact that it occupies one third of the publication. It is however unfortunate that pre mminence is thereby given to Doctor Smith's arguments for political action Although quite valid these arguments are unlikely to encourage those readers who wish to be more active in this field within their own Clinical Practice or find favour amongst those who would resist further political restriction of their own freedom to enjoy moderate drinking

Those who read on (rather than lobby their Member of Parliament) are rewarded by a useful summary

of basic facts about the [illegible] a review of the consequences of excessive drinking [illegible] the guidelines on detection and intervention [illegible] tempting to say that this is a superficial treatment of its subject—the publication does not aspire to more—but the result whilst advocating early intervention [illegible] lacks information on the behaviour and problems associated with abnormal drinking and [illegible] real flavour of the experience of dependence. It is also a pity that the final section which mentions the value of constructive coercion (already well established in the Royal Navy) was not expanded. This title offers a useful reference for those wishing to increase their knowledge of the effects of alcohol abuse in our society or to provide education for others but for the Physician embarking on any attempt to help problem drinkers at the optimum time it is too limited in scope to be more than an introduction. This limitation is however likely to be balanced by the provision of an inexpensive and concise volume which should stimulate more action in this worthwhile field.

ABC of Diabetes, 2nd Edition Peter J Watkins British Medical Journal 1988 Inland £4 95 Abroad £6 50 USA $11 00

In the last 15 years there have been enormous advances in the philosophy and the practicalities of diabetic management. Dietary advice has been transformed. U100 insulin, human insulin and new insulin delivery systems have revolutionised care of the type I patient and home blood glucose monitoring has made a different order of control possible for all. The increasing evidence that good diabetic control prevents or delays the onset of the complications, previously thought inevitable, and probably reduces their severity has been the stimulus to many of these advances.

Peter Watkins's articles were originally published in the BMJ as part of the ABC series in 1982 and collected into the first edition of this book five years ago. This second edition has been updated in some parts but much of the original text and most of the figures remain. It is a straightforward didactic review of the disease, its management and the organisation of diabetic care, aimed at the non-specialist. Sadly there are no excursions or even glimpses into some of the exciting newer ideas on aetiology, mechanisms and therapy. However all that is there is sound, sensible and clear, making this a valuable and balanced basic text for all who deal with diabetic patients. Because the second edition update has been limited and progress has been rapid some sections are beginning to show their age. The dietary guidelines were clarified by the ADA in 1979 and the BDA in 1981 but are wholly in this presentation. The importance of home blood glucose monitoring is quite rightly emphasised but continuous subcutaneous insulin infusion which is rarely used receives disproportionate discussion. Dis[illegible] diabetes is important and covered well. Many of the figures are dated in the equipment shown and by the omission of such automatic capillary blood samplers.

This is a valuable introduction to or update in diabetes for non experts but in need of a much more radical update than has been done in this new edition.

RHT

MCQ's and Short Notes in Psychiatry Alistair S Burns, Anthony S David & Michael Parrell Pp 130 Butterworth & Company 1988 £6 95

This small book is specifically aimed at psychiatric trainees to give experience of those newer aspects of the Part I and Part II Membership Examination.

It offers 180 multiple choice questions together with answers and useful additional explanatory notes.

There is a further short section giving typical questions and specimen answers for the new Short Answer Question Paper in the Membership Exam.

The suggested further reading is limited to a sensible short list of books most of which will already be familiar to the psychiatric trainee nearing exam time.

The questions are grouped according to major area of topics covered thereby not only allowing the trainee to concentrate his efforts in weak areas and to revise topic areas in their entirety but also making the book useful as a brief notes reference book for future use.

Whilst not all areas are covered fully the book is generally well balanced and the question formats are generally good. It is particularly difficult to devise MCQ questions which avoid semantic traps and questions of opinion but there is little in this book which would cause major disagreement.

I consider this to be one of the better books of this style and would certainly recommend it to trainees in psychiatry.

EJCB

Prevention of Coronary Heart Disease and Stroke Julian Tudor Hart, Barbara Stilwell and J A Muir Pp 244 Faber & Faber 1988 £5 95

This textbook is an enthusiastic and ambitious attempt to provide a workbook for Primary Care teams in prevention of Coronary Heart Disease and Stroke. The Authors main objective is to stress the importance of preventive medicine and to give advice by example to all members of the Community Health team.

They describe the concepts, methods and techniques of screening patients within the Community for the management of smoking, obesity, hypertension, glucose intolerance and high blood cholesterols etc. There are numerous tables and figures to show examples of the size of the problem and those most at risk, taking into account the effects of age, sex, social class and regional differences. It also describes the different methods for further training and education of staff and the financial help available. The material has been drawn from diverse sources and there are

many useful references and suggestions for further reading.

This topic covers a broad spectrum and preventive medicine is often more difficult than curative. However much is now going on in this country as well as abroad to develop preventive work in general practice. The authors have tried to give advice from a medical and nursing point of view and in my opinion lay down the necessary guidelines for any practice to set up or improve an existing system of screening. They hope to give encouragement to all members of the primary care team to strive for improvements in prevention of Coronary Heart Disease and Stroke. Whether or not they succeed remains to be seen.

JMS

Logic in Medicine. Ed Colbert C Phillips.

This book is one of a series of Pocket Books of Collected Articles from the BMJ. It is dedicated to Sir Peter Medawar and addresses some of the fundamental principles of logic and philosophy that underlie the Clinical and Health Care decisions that professionals make intuitively. I have to report that it is for the most part very hard-going, particularly for those unfamiliar with the jargon of Formal Logic and with the eponymous titles of the various systems of problem analysis. An effort is made to explain terminology and initiate the newcomer but space is too short for much success. Some of the chapters are more manageable and these make informative and enjoyable reading. For example Economic Perspectives by Professor Maynard, Ethical Principles by Ian Thompson and Clinical Decision Making by Dr Knill-Jones.

This is a scholarly book which does credit to its contributors but it is I fear for a limited number of erudite and determined readers.

RR

Emergency Procedures and First Aid for Nurses, 2nd Edition. Ed Muriel Skeet.

The publishers state that the book is a practical manual for nurses on the emergency procedures they may need to performed both in and out of hospital.

It is recognised that many nurses knowledge of basic first aid is weak and this volume covers this aspect of emergencies clearly and concisely. The approach is that of principles of care. Therefore some procedures may not correspond with those laid down by the RN First Aid School. However all are approved by various specialist centres. The section on accidents in the home and sports injuries are particularly pertinent.

The disadvantage of the text is the combining of First Aid outside the hospital environment and emergency treatment and management within. When in a First Aid situation does one have a sphygmomanometer or defibrilator to hand?

The advanced aspects of the text precludes the book from being used by new entry nurses for whom basic First Aid is an important element of training, but who has yet to gain the background knowledge for the detailed aspects of patient resuscitation in hospital.

Throughout the book the text is neat and well supported by line diagrams and photographs both black and white and coloured and is bound in a soft cover.

This is the 2nd Edition of the book and the new chapters on major traumas combined with the detailed information concerning hospital emergency situations makes this a useful book for the Senior Student as a means of revision for basic First Aid and a guide to hospital emergency procedures.

HRMS

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LETTERS TO THE EDITOR

Sir

Having successfully managed over five hundred cases of heat illness I was concerned to see Surgeon Lieutenant Travis advice on the management of heat stroke As yet I have not managed to obtain a copy of the publication that he quotes in justify the use of evaporative cooling but I can state from vast experience that this has no part to play in the treatment of the exercise related heat illness that our Medical Officers see in the United Kingdom The treatment of choice in these severely ill casualties is intravenous normal saline in large quantities We give two litres in the first ten minutes routinely followed by a further two litres It takes not to twenty minutes to get the rectal temperature down to 37°C and we have had no problem with rebound hypothermia Evaporative cooling may not work in these UK casualties as they have minimal skin circulation exhibiting itself by the pallor of the patient who feels cool to touch

The reason for this letter is my anxiety that medical staff may waste time setting up fans wet sheets and showers when they should be rehydrating the patient As Surgeon Lieutenant Travis correctly states time is of the essence Rapid aggressive rehydration with normal saline may prevent a tragedy such as that reported by Surgeon Lieutenant Jarmulovicz and Surgeon Commander Buchanan in the same issue of the Journal

Yours faithfully

D I RIDDELL
Surgeon Commander RN
PMO CTCRM

Sir

I was very interested to read the article by Surgeon Commander Carmichael in the Spring issue about the lessons learnt from Chernobyl I would be grateful to have the chance to make some comments from a haematologist s standpoint

Allogeneic bone marrow transplantation usually includes total body irradiation of about 6 5–14 Gy to the bone marrow depending on age and size of patient this is well in excess of the quoted LD_{50} for fit adults As a consequence haematologists are now expert in the care of these neutropaenic and immunocomprised patients during the three or four weeks before marrow recovery This support includes prophylactic gut decontamination use of prophylactic acyclovir against herpes simplex re-activation use of red cell and platelet concentrates which must be irradiated to reduce the incidence of severe Graft Host Disease and general intensive care Bacterial septicaemias as well as invasive fungal infections and septicaemias commonly occur and their management with broad spectrum anti bacterial and anti fungal antibiotics is now routine These support strategies were used successfully at Chernobyl demonstrating that those receiving up to 8 Gy total body dose can be kept alive until spontaneous autologous reconstitution occurs

Although not used at Chernobyl the recombinant growth factor GM CSF (Granulocyte Macrophage Colony Stimulating Factor) can produce useful increases in circulating neutrophils even in those who have received in excess of 6 Gy This has been used with some success in the recent incident involving Caesium in Brazil and is a treatment where further experience of its use following chemo/radiotherapy will influence management of casualties to any future accident

The possible benefit of allogeneic bone marrow transplants at Chernobyl was difficult to interpret because of the difficulty of tissue typing these in need and the complications resulting from their other injuries Transplantation may have a limited place in the management of radiation casualties

Clearly at Chernobyl and probably in future accidents other injuries prejudice the chance of survival and strict triage criteria taking into account the radiation dose received and other injuries must be applied. The following plan has been suggested [1]

Dose received (Gy)	Action
<1	Follow as outpatient
1–3	Close observation
3–8	Hospitalise—use GM-CSF
>8	Consider BMT
>15	Support. Death inevitable due to multi-organ damage.

The LD_{50} for fit adults may lie between 3 and 5 Gy[1] however it would be more valuable to know the LD_{10} and LD_{90} for humans receiving full support. This knowledge would allow informed decisions about when to use high risk procedures such as bone marrow transplants and when to avoid them.

I conclude that the experience gained at Chernobyl and latterly in Brazil have demonstrated that current management techniques developed and routinely used by haematologists can save many who have received large radiation doses. The cost and logistics of these techniques mean they can only be applied successfully to a few casualties and are more applicable to peacetime radiation accidents than war time radiation casualties.

The Royal Navy Medical Service has a special interest in the management of radiation accidents and there is extensive radiological protection experience available. I believe that a team of clinicians and radiological protection specialists should be founded on a single or multi-service basis to provide a core of clinical management expertise readily available to aid in civilian or military radiation accidents and to advise how current techniques could be applied to radiation casualties in war.

I am Sir Your obedient servant

C M JAMES MB MRCP(UK)
Surgeon Lieutenant Commander Royal Navy
Senior Specialist in Pathology

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Sir

Manual Performance and Finger Temperature

The interesting article by Litchfield on Manual Performance in the Cold (Vol 3 1987 p 175) does not mention the level of hand skin temperature (HST) that may be reached during work in a cold environment. The HST commonly experienced during work in sub zero temperatures has implications for the recognition and prevention of cold injury. Steegman[1] demonstrated that the finger tip temperatures of Ojibwa Indians in the Canadian Arctic may drop to 2.5°C during tally tasks.

Conduction velocity in somatic nerves decreases at nerve temperatures below 25°C[2] and skin receptor desensitisation corresponding to the sensation of numbness, occurs below 10°C[3]. The skin surface temperature, however cannot be assumed to represent the digital nerve temperature even though the median nerve temperature at the wrist has been measured at only 1°C higher than the surface[4].

Once the fingers are numb no further drop in peripheral temperature can be sensed by the individual during continued exposure. This means that cold injury can occur unrecognised although the actual skin temperature at which injury occurs remains unknown. This is a vital training point to prevent cold injury to the hand: fingers must be rewarmed (eg under the armpit) as soon as fingers become numb. That this simple advice needs to be stated is shown by the incidence of frostnip and frostbite of the fingers amongst troops deployed to Norway[5].

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The author was invited to reply

Sir

Manual Performance and Finger Temperature

Travis makes valid points about the need for both vigilance and early rewarming if cold injury to the hand is to be prevented when working in cold climates. However my review article specifically avoided consideration of cold injury since both the pathogenesis[1] and the practical implications[2] have so recently been discussed in the Journal.

The cold effect upon conduction velocity and skin receptor desensitisation are certainly important factors in dexterity impairment. However as discussed in the review the overall effect is likely to be multifactorial since a direct vascular response[2] and changes in viscosity of synovial fluid[4] have also been described.

There are dangers in extrapolating results obtained in highly selected ethnic groups to the general population. Abnormal tolerance to cold has been described not just in Ojibwa Indians but in a variety of racial groups[5, 6, 7] and this has usually been attributed to a modification of the cold vasodilatation response. Additionally habituation of personnel not normally exposed to extreme cold can occur[8] and hence the review article advised that great care must be taken to avoid confounding factors when studying this complex subject.

P LITCHFIELD
Surgeon Commander

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OBITUARIES

Surgeon Lieutenant C R Ingamells MB ChB MRCGP Royal Navy died unexpectedly on the 15th of May 1988 at sea in HMS *Gloucester* at the age of 29

Surgeon Lieutenant Commander N J Cripps writes

Christopher Robert Ingamells was brought up and educated in Norfolk becoming head boy of his school before entering Edinburgh University Medical School. He had the singular honour of becoming Senior President of the Royal Medical Society in his fourth year and of being elected Fellow in 1982 the same year in which he graduated.

Chris entered the Royal Navy as a Medical Cadet in 1979. As an Acting Surgeon Lieutenant he undertook both pre-registration appointments in the Royal Naval Hospital *Haslar* in 1982–83 where he instantly demonstrated a considerable professional ability whilst living life to the full. It was during this time that the "Ingamells Bat Virus" was first recognised.

As a Surgeon Lieutenant on completion of his house-jobs, he underwent New Entry Medical Officer training at BRNC *Dartmouth* and the Institute of Naval Medicine followed by Submarine Medical Officer training at HMS *Dolphin* and RNEC *Greenwich*.

His first sea appointment was to HMS *Sceptre* where he soon gained his Dolphins and then to HMS *Rutland* (SSN) He was a charming and likeable young medical officer and was soon recognised as a valuable member of the submarine team. Chris enjoyed being a submariner and was always proud to wear the submarine badge but he was at heart, a doctor and for clinical responsibility.

Returning from his first submarine patrol Chris became engaged to Mandy Bordie whom he had earlier met whilst doing a locum and they were later married in February 1985.

Chris chose General Practice for his career and in 1985 he was appointed to Royal Marines *Deal* as Medical Officer with associated GP training in one of the Deal group practices. At the end of that year he demonstrated his dedication to his new specialty by passing the examination for Membership of the Royal College of General Practitioners at the first attempt a considerable achievement having had a relatively limited prior clinical exposure.

His appointment in Deal was not slightly short by what would prove to be his final appointment to HMS *Gloucester* for an Armilla patrol. He had only recently extended his Short Service Commission by three years and was eager to sample aspects of the "submariner life".

Everything Chris attempted was with zeal and zest and he always gained the maximum from whatever situation he found himself in. He made friends readily and easily gained the respect of all with whom he worked. He was a caring and compassionate doctor and a talented officer in whose capable hands his Captains confidently left their medical problems.

His interests outside medicine were many and varied and from these Chris gained much relaxation. He played many games especially golf and hockey and enjoyed classical music both by listening to it and by playing it on the tuba. Chris achieved a great deal in his short life.

He is survived by his mother Cathy and two sisters and by his devoted wife Mandy and young son Alexander to all of whom we extend our deepest sympathy.

Surgeon Lieutenant Commander (D) A M Prosser BDS RN died on 19 April 1988 in the age of 31

Mrs Catherine Williams BDS writes

Despite his relative youth Surgeon Lieutenant Commander (D) Prosser was a most respected and distinguished member of the Royal Naval Dental Branch. All who knew him will be saddened by his recent untimely death at the age of 31 after a long and courageous struggle against Hodgkin's disease.

Andrew was educated at King Edward's School Bath and had an outstanding dental undergraduate career at Bristol University Dental School. He joined the Royal Navy as a Cadet in 1978 and commenced his Short Career Commission as a Surgeon Lieutenant (D) in January 1980. His first appointment was to HMS *Drake* where he quickly gained a reputation as a hard working and a keen sportsman. These and other qualities led to his selection for service with the Royal

Marines and successful completion of the All Arms Commando Course.

April 1982 saw Andrew embarked in SS *Canberra* bound for service with 40 Commando Royal Marines in the South Atlantic. For most of the Campaign he was based in the San Carlos area working in the Regimental Aid Post throughout what was almost continuous air attack. Returning from the Falklands he found that the British Joint Services Expedition to Peru for which he had earlier been selected had been postponed due to the hostilities thus enabling him to take part. His principal role in this expedition was to set up a pioneering medical and dental programme for Peruvian Indians in the Amazon headwaters. On return from Peru in December 1982 he rejoined his Commando Unit for active service in South Armagh and it was towards the end of this deployment that he became unwell and Hodgkin's disease was diagnosed.

By the beginning of 1984 he seemed to be fully recovered and he married Jennie. But during his next appointment at HMS *Raleigh* signs of the previous illness reappeared. He then showed remarkable courage and remained hard working and cheerful throughout a long period of potent chemo-therapy. He was awarded the *Harvey Fletcher Prize* as recognition of exceptional service to the RN Dental Branch in 1985. On left the Royal Navy that year on completion of his Short Career Commission and proceeded to work diligently in general dental practice despite again having to undergo protracted periods of treatment. This remarkable and courageous young dental surgeon died peacefully in April 1988. All who knew him remember a kind and very caring person.

The heartfelt sympathy of all Andrew Prosser's Service and ex Service colleagues is extended to his wife Jennie and to his parents Mike and Jean. His resilience and courage remain an example to us all.

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SERVICE NEWS

ROYAL NAVAL MEDICAL AND DENTAL OFFICERS

HONOURS

The Most Venerable Order of the Hospital of St John of Jerusalem

Commander (Brother)
Surgeon Commander W H B Ellis RN Retired

COMMANDER IN-CHIEF'S COMMENDATION

Surgeon Lieutenant G L Greenslade RN
HMS Herald

At 2030 local time on 26 February 1988 HMS *Herald* was conducting hydrographic surveys off Jebel Ali in the United Arab Emirates when a young rating, working in the ship's motor room, sustained serious injuries to both feet with significant loss of blood when they became trapped in a revolving gear wheel attached to the main propeller shaft.

Immediate first aid supervised by Surgeon Lieutenant Greenslade prevented loss of life but at first sight it looked as if one or both feet may have required amputation. Over the following three hours Surgeon Lieutenant Greenslade undertook vigorous intravenous fluid replacement combined with a calm and careful appreciation of pain relieving requirements before it was considered prudent to subject the injured man to the vertical lift through several decks to the sick bay.

Over the succeeding hours while the ship was heading for shore Surgeon Lieutenant Greenslade undertook essential and very skilful primary surgical repairs to conserve the remaining circulation to the feet thereby limiting tissue damage. Thereafter he remained with his patient during the transfer ashore ensuring that no deterioration occurred and assisted in the subsequent definitive surgery at the Rashid Hospital in Dubai four hours later.

I commend Surgeon Lieutenant Greenslade for his professionalism, skill and calmness under pressure. That both the injured man's feet were ultimately saved is a direct consequence of the prompt, expert and sonnally exceeded first aid and primary surgery that he received onboard HMS *Herald*. The calming reassurance that Surgeon Lieutenant Greenslade both gave and displayed to the potentially crippled man shortly after the traumatic accident greatly reduced the psychological trauma on the young man. Undoubtedly Surgeon Lieutenant Greenslade's actions were in the highest traditions of both his Branch and the Service.

APPOINTMENTS AND PROMOTIONS

To Surgeon Rear Admiral (OMS)
10 January 1989
Surgeon Rear Admiral RE Snow LVO OBE QHP

To Surgeon Rear Admiral and Appointed SRA(SMS)
3 January 1989
Surgeon Captain DA Lammiman LVO QHS

To Surgeon Commodore (NMT) and Dean of Naval Medicine
14 November 1988
Surgeon Captain F R Wilkes MDC

To Medical Officer in Charge Royal Naval Hospital Haslar
13 December 1988
Surgeon Captain F St C Golden OBE

To Medical Officer in Charge Royal Naval Hospital Plymouth
15 November 1988
Surgeon Captain D L Swain LVO

To Medical Officer in Charge Institute of Naval Medicine
10 January 1989
Surgeon Captain A Craig

As Consultant Adviser in Anaesthetics in MDG(N)
4 July 1988
Surgeon Commander S D Merrill

As Consultant Adviser in Aviation Medicine to MDG(N)
9 August 1988
Surgeon Commander N E Baldock

To Surgeon Commander (D)
J Harker (30 June 1988)

To Surgeon Lieutenant Commander
D R Batham F M Craig McFeely
N A Hedger D A Hill
J M Inwood D N Jones
R M McGill G A Moyse
N F J Scott Moncrieff S C Sheard
T J W Spalding N B Stevens
F K Westwood C Pipkin
N P J Cripps, S L Hotkinson
R N Morley

Provisional Selection for Promotion to date 31 December 1938
To Surgeon Captain
M P W H Paine
I L Jenkins

To Surgeon Captain (D)
R S Hambly

To Surgeon Commander
R Adley R H Taylor
T J R Francis R J Clark

To Surgeon Commander (D)
M W Weston S D B Taylor

To Surgeon Lieutenant
P R Davies J R Mackay
F P O Kelly D J Summerton
S E F Bree M A Glover
R J Guy M D Stewart
M D Stoneham

To Surgeon Lieutenant (D)
A G Cooper C D J Redman

To Acting Surgeon Lieutenant
A R Bailey D J Fitt
C W Booth J M Clarke
A K Dashfield R J Davidson
A Fulchett S P Hambling
R M Hayes C R Jones
D A Jones A L M Judd
J W B Ross G C O Shelford
D C Mackay

HIGHER QUALIFICATIONS
Surgeon Lieutenant Commander
T J W Spalding—FRCS(Edin)
Surgeon Lieutenant Commander
N P J Cripps—FRCS(Edin)
Surgeon Lieutenant Commander
D N Jones—MRCGP
Surgeon Lieutenant A Logan—MRCGP
Surgeon Lieutenant Commander
N A Hedger—AFOM
Surgeon Lieutenant Commander
S J Ryder—AFOM DIH
Surgeon Commander H A Chandler—MRCPath

Apologies to Surgeon Lieutenant Commander L J Jarvis whose Higher Qualification of FRCK was printed as FRCF in the Summer edition of the Journal

NEW ENTRIES
Surgeon Lieutenant Commander M R Dean

Surgeon Lieutenants
Miss K E Blaydes, T S J Walker

Surgeon Lieutenants (D)
A M Grew K F Pilgrim
R J Colbeck

Surgeon Sub Lieutenants
D B Badham V Maitland
S J Leigh-Smith S W S Millar
D W Oliver

PLACED ON RETIRED LIST
Surgeon Captain H B Blackstone
Surgeon Commander J G Williams

PLACED ON EMERGENCY LIST
Surgeon Lieutenant Commanders
D Farmer M T N Knight
B Conroy P M Craig-McFeely
N B Stevens R N Morley
Surgeon Lieutenant Commander (D)
H R Davies J N A Farrier

Surgeon Lieutenants
M J Shuter K J Watson
C M Wilson J P Miell
A Logan

QUEEN ALEXANDRA'S ROYAL NAVAL NURSING SERVICE

PROMOTIONS
To Principal Nursing Officer—Miss J Titley ARRC
To Chief Nursing Officer—Miss C M Taylor ARRC

To Superintending Nursing Officer
Miss S Cronghart
Miss L Gibbon

To Senior Nursing Officer
Miss L Archer
Mr M Bowen
Mr M N Harvey

NEW ENTRIES

Senior Nursing Officer—Mrs S C A Meldrum
Nursing Officer—Miss F S Hall
Nursing Officer—Miss E J Kirby

WITHDRAWN ON COMPLETION OF SHORT CAREER COMMISSION

Senior Nursing Officers
Miss J M Stephanie
Miss L T Pearl
Mrs F M J Lydiate

ROYAL NAVAL RESERVE

PROMOTIONS

To Surgeon Commander (D)
D Higgs—31 December 1988—*Vivid*

To Surgeon Lieutenant Commander (D)
R A Baker—*President*

To Surgeon Lieutenant Commander
D J Sherstone—*Eaglet*
L E Shutt—*Flying Fox*
P K Small—*Claverhouse*

NEW ENTRIES

Surgeon Lieutenant Commander
M J C Wale—*Sherwood*

Surgeon Lieutenants
A Naylor—*Sussex*

Surgeon Lieutenant (D)
R K Bennett—*Eaglet*

Probationary Surgeon Sub Lieutenant
C E Gunn—*Camperdown*
S R C Smith—*Claverhouse*

Probationary Surgeon Sub Lieutenant (D)
M D Park—*Culhope*
C S Lambert—*Flying Fox*

RETIREMENTS

Surgeon Lieutenant Commanders
G S Kenyon—*President*
D G Millar—*Cochrane*
D F Baigent—*Sherwood*

Apologies to Surgeon Lieutenant Commander (D) G H Irvine (*Flying Fox*) whose Promotion was quoted as Surgeon Commander (D) in the Summer Edition

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